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REQUIRING SECONDARY MATERIALS IN FEDERAL CONSTRUCTION

A FEASIBILITY STUDY

RESOURCE PLANNING ASSOCIATES

JANUARY 1975

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The Federal Government is the largest single purchaser of construction in the United States, accounting for approximately 18 percent of total annual construction. The study examines the feasibility of the Government's using this considerable purchasing power to require the use of secondary materials in construction products as a means of increasing recycling.

The analysis of Federal construction procurement policies, laws, regulations, and funding levels shows that while the Government is a major purchaser of construction materials, there are significant constraints to requiring recycled materials in these products.

An in-depth technical and economic analysis of opportunities to use secondary materials recovered from the municipal solid waste stream shows that Federal construction procurement could impact significantly on the materials in the municipal solid waste stream.

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IN FEDERAL CONSTRUCTION-
A FEASIBILITY STUDY

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U.S. ENVIRONMENTAL PROTECTION AGENCY

1975

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ABSTRACT

The Federal Government is the largest single purchaser of construction in the United States, accounting for approximately 18 percent of total annual new construction. The study examines the feasibility of the Government's using this considerable purchasing power to require the use of secondary materials in construction products as a means of increasing recycling.

The analysis of Federal construction procurement policies, laws, regulations, and funding levels shows that while the Government is a major purchaser of construction materials, there are significant constraints to requiring recycled materials in these products. For example, 78 percent of federally supported construction is in the form of grants and loans to state and local governments. Federal control over the use of these indirect funds is less than for direct-procured construction projects.

An in-depth technical and economic analysis of opportunities to use secondary materials recovered from the municipal solid waste stream shows that Federal construction procurement could impact significantly on the ferrous and glass fractions. Post-consumer ferrous scrap presents an immediate opportunity for use in the lower grade steel construction products such as reinforcing bars. Waste glass, on the other hand, is a longer-term opportunity, due to the limited availability of the low quality, low value waste glass from resource recovery plants. The development of these plants is still in its infancy.

The report recommends the following: that emphasis be placed on requiring post-consumer ferrous scrap in steel construction products; that the Government provide markets for the newly emerging construction products made from waste glass; and that construction contract specifications encourage the use of secondary materials in all products, consistent with performance requirements.

STUDY OF THE FEASIBILITY OF REQUIRING SECONDARY MATERIALS IN FEDERAL CONSTRUCTION

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SUMMARY OF FINDINGS AND RECOMMENDATIONS

The Federal Government purchases, either directly or indirectly, approximately 18 percent of annual new construction in the United States. In Fiscal Year (FY) 1973 this amounted to nearly $22.5 billion, of which approximately 40 percent, or $9 billion, was spent on construction materials. The following is a summary of findings related to the feasibility of using this considerable purchasing power to increase the use of recycled materials in construction products.

FINDINGS

There are two major types of construction procurement - direct and indirect. In the former, the Federal Government contracts directly with a construction contractor. The latter involves the distribution of grants and loans to state and local governments for construction purposes. Direct procurement accounts for about 22 percent of federally supported construction; indirect represents 78 percent.

Federal construction procurement is controlled through the use of several different types of specifications and guidelines, which could be modified to require the use of recycled materials. For direct procurement, these specifications take the form of detailed instructions to the designer and builder concerning all phases of the construction process, including requirements for construction materials. On the other hand, the guidelines for indirect procurement typically provide only general technical guidance and broad performance requirements. The choice of construction materials is usually left to the grant/loan recipient.

Thus, while the Government would appear to have the legal authority to specify recycled materials in all types of construction, implementation of this requirement for indirect programs would result in some administrative complexity and require the modification of existing agency procedures. Implementation for direct programs would be less complex.

The majority of Federal construction funding and materials purchases is concentrated in a small group of agencies. The Department of Transportation is by far the largest, funding over $5.7 billion in FY 1973 - 35 percent of total federal construction outlays. Other key agencies include the Department of Defense (including Army Corps of Engineers Civil Works Construction); Department of Health, Education, and Welfare; Department of Agriculture; and the Environmental Protection Agency.

There are a number of attractive opportunities to use recycled materials in construction products, and these are summarized briefly below.

Ferrous Scrap

Federal purchases of iron and steel construction products could use nearly 500,000 tons of municipal can scrap annually, or 8 percent of the ferrous containers in municipal solid waste. Although there would be some industry resistance to specifications requiring the use of municipal ferrous scrap - especially for steel reinforcing bars - this is not considered to be an insurmountable problem.

Waste Glass

Federal purchases of construction materials could consume as much as 1.43 million tons of waste glass annually - 12 percent of the glass containers in municipal waste. This is more of a long-term opportunity, since these products use the lower quality cullet from resource recovery plants - and significant quantities of this material are not likely to be available before 1980. Most of the products that use waste glass have gained only limited market acceptance; only a few have been developed past the pilot/demonstration stage.

Plastic Scrap

The Federal Government could influence the use of about 30,000 tons of post consumer waste plastics in its construction purchases, or 1 percent of plastics in the waste stream. A major problem with this material is the limited supply of post consumer waste plastic. The difficulties associated with separating plastic polymers is a major barrier to recycling.

Waste Paper

Federal construction could consume an additional 460,000 tons of waste paper, or 1.5 percent of the paper in municipal waste. The General Services Administration has already taken steps to require waste paper usage in two important construction materials - construction paper and insulating board.

RECOMMENDATIONS

The findings detailed in the following report and summarized above led to the following recommendations for Federal construction procurement policy.

1. Emphasis should be placed on using post consumer (municipal) ferrous scrap in iron and steel construction products. Initially the program might involve only one agency. For example, the Department of Transportation could modify its specifications to require that some percentage (say 5 percent) of municipal scrap be used in reinforcing steel installed in all federal-aid highway projects.

2. Where practicable, the Government should use its purchasing influence to provide markets for the newly emerging construction products made from waste glass. Given the limited availability of these products, procurement would be on a case-by-case, demonstration basis.

3. All Federal construction contracts should encourage the use of secondary materials in construction products, consistent with product performance requirements.

I. INTRODUCTION

There has been considerable interest in recent years in the use of Federal purchasing power to encourage either the reduction of solid waste generation or the use of recycled materials. Section 205 of the Resource Recovery Act of 1970 (Public Law 91-512) requested that a study be made of the "use of Federal procurement to develop market demands for recovered resources." Several bills currently before Congress include specific requirements that all federally procured materials contain recycled materials to the maximum extent practicable. And in 1971 the General Services Administration (GSA) changed its paper procurement policy to require specific percentages of recycled materials in a number of the paper products purchased by the government.

In compliance with the 1970 Act, the Environmental Protection Agency (EPA) authorized a study in 1971 to determine those areas in which the Federal Government's procurement power could be utilized most effectively as an economic incentive to increase the use of recycled materials. This study identified several areas of Federal procurement, including construction materials, with potentially significant recycling impacts.

The present study was authorized to provide a detailed analysis of the Federal Government's procurement of construction materials and of the opportunities to use municipal waste materials in construction products. The objective of this analysis is the development of recommendations for a Federal procurement policy that will result in significant recycling and, at the same time, minimize the associated economic and institutional problems for both industry and the Federal agencies involved.

To this end, the body of the report is organized into two major sections, as follows:

> Chapter II - "Federal Construction Procurement" provides an overview of the construction industry and a detailed discussion of the Federal construction procurement process.
>
> Chapter III - "Opportunities To Use Wastes in Construction Materials" analyzes the opportunities to use municipal wastes in construction products, assesses the potential Federal impacts in each of the four waste categories analyzed (i.e., ferrous, glass, plastic, and paper), and summarizes the constraints associated with each.

II. FEDERAL CONSTRUCTION PROCUREMENT

A prerequisite to the development of a sound Federal construction materials procurement policy is an understanding of the construction industry and the Government's role in construction, as well as the Federal construction procurement process. Hence, the major sections of this chapter cover:

A. "Construction Overview," which describes the construction industry in general and the Federal share of national construction activity.

B. "Federal Construction Procurement Process," which details the ways in which the Federal Government purchases construction, including the laws and regulations that pertain to Federal construction procurement and the specifications for Federal construction projects.

C. "Federal Procurement Analysis," which describes the construction programs of Federal agencies, the types and amounts of facilities funded, and the quantities of construction materials purchased.

D. "Federal Activities Related to Procurement of Secondary Materials," which summarizes the existing programs within Federal agencies to procure products containing recycled materials or to conduct research and demonstration programs related to the use of recycled materials in certain product types.

A. CONSTRUCTION OVERVIEW

To understand how the Federal Government might use its considerable purchasing power in construction to provide markets for recycled materials, it is important to understand the construction industry in general and the role of the Federal Government in construction. Each of these two topics is addressed in turn in this section.

THE CONSTRUCTION INDUSTRY AND ITS PROCUREMENT PROCESS

Total new construction* in the United States in 1972 amounted to $123.8 billion, or about 11 percent of the $1,151.8 billion gross national product.[1] (Table 1 presents a breakdown of 1972 new construction projects, by private versus public ownership and by major facility types.) On the average, construction materials account for about 40 percent of the cost of new construction projects.[2] In 1972, the sale of construction materials amounted to $50 billion, or about 4 percent of the gross national product.

The execution of a construction project consists of two major phases, design and construction. (See Figure 1 for an overview of the process.)

Design Phase

In the design phase, the architect-engineer (A-E) develops the requirements of the facility owner into project plans and specifications, which contain complete instructions on the type and quantities of construction materials required, and direct the way in which these materials are to be put together to form the completed facility. If the owner has a design staff, this work may be done in-house; if not, the A-E is typically selected on the basis of both his estimated design fee and his professional reputation and experience.

Upon completion of the design work, the owner solicits bids on the plans and specifications from construction contractors. The lowest bidder is usually awarded the construction contract. For most projects, several different construction specialties are involved, and each is performed by a subcontractor who specializes in a particular field. The owner deals directly with the general contractor, who, in addition to performing a portion of the work, coordinates the activities of the various subcontractors.

This construction contracting industry, consisting of general contractors and subcontractors, is extremely fragmented. As of 1967,

---

*Construction in the broadest sense includes the erection, maintenance, and repair of immobile structures and facilities, such as buildings for residential, commercial, industrial, educational, religious, charitable, and public use, as well as highways, dams, airports, and tunnels. This study was concerned with only new construction, since maintenance and repair account for less than 5 percent of total federally funded construction expenditures.

[1] U.S. Department of Commerce, Statistical Abstract, 1973.

[2] Ibid.

Table 1

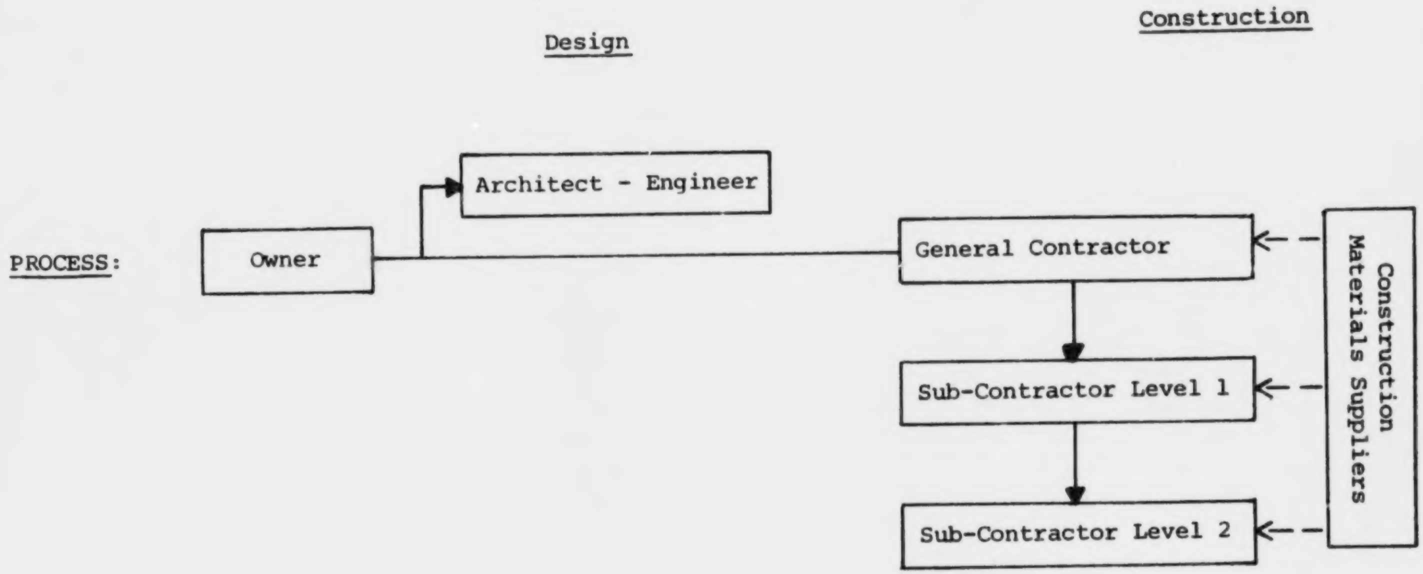
New Construction - 1972*

Ownership		$ Billion
Private		$ 93.6
Residential	54.2	
Nonresidential	39.4	
Public		30.2
Total		$ 123.8
Facility Type		
Buildings		$ 89.7
Public Utilities		13.6
Highways and Streets		10.4
Other Public Works		10.1
Total		$ 123.8

*Source: U.S. Department of Commerce, Statistical Abstract, 1973.

Figure 1

CONSTRUCTION PROCUREMENT PROCESS


Design
Construction
PROCESS:
Owner
Architect - Engineer
General Contractor
Sub-Contractor Level 1
Sub-Contractor Level 2
Construction Materials Suppliers

nearly 800,000 firms in the U.S. were engaged in construction contracting.[3] Of this total, approximately 130,000 were general contractors (100,000 general building contractors and 30,000 general heavy construction contractors, specializing in highways and earthwork). The remaining 670,000 were subcontractors, specializing in one of the 16 or more building trades, ranging from plumbing to structural steel erection.

Each year, over 100,000 firms enter the industry, while a comparable number leave. Rapid entry is facilitated by the minimal equipment needed for a small-scale operation - a shovel and hammer are sometimes sufficient, and frequently even a pickup truck is not necessary. Moreover, failures occur continually due to lack of experience and poor management, which lead to high operating expenses and inadequate sales. The turnover rate in construction is thus higher than in any other major industry.[4]

In 1967, over 75 percent of the 800,000 construction contracting firms had annual sales of less than $100,000; more than half of these had sales less than $10,000.[5] The top 400 general construction contractors (excluding home builders) accounted for approximately 33 percent of total new construction; the top 40 represented about 20 percent of the total. The largest general construction contractor has a market share of 1 to 2 percent.

Construction Phase

During the construction phase, the general contractor and the subcontractors obtain their required materials from one or more material suppliers. The construction materials industry can be characterized by its extreme complexity. This industry is, in fact, made up of numerous types and sizes of firms from many industries. The broad scope of the industry can be better understood by observing Figure 2.

Construction materials are manufactured by companies that also produce goods for a wide range of other end-use industries. For example, steel companies manufacture steel products not only for

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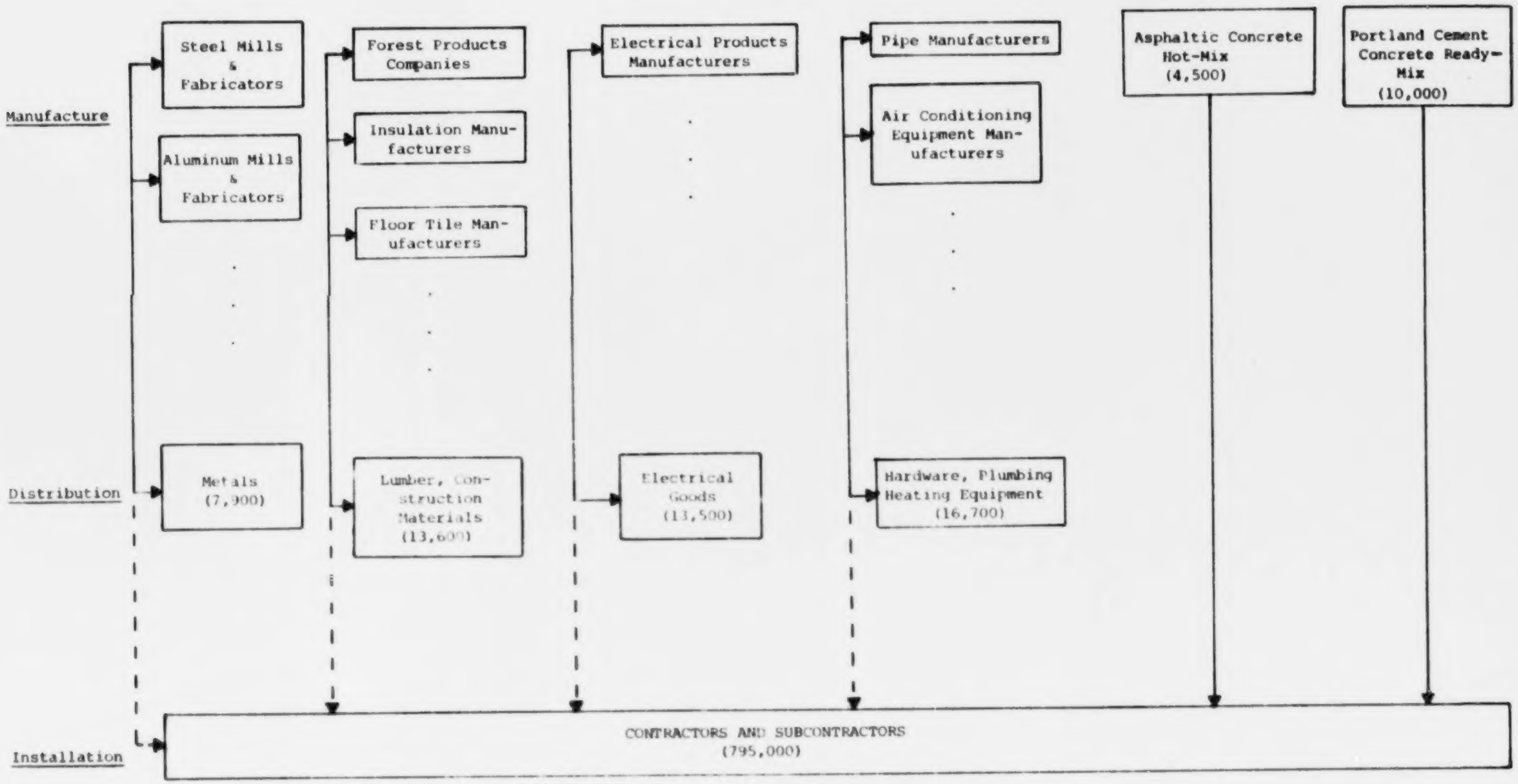
[3] U.S. Department of Commerce, Statistical Abstract, 1973.

[4] Rees, John D., "The Birth of Construction Management," Research Report submitted for Harvard MBA Program, April, 1972.

[5] U.S. Department of Commerce, Statistical Abstract, 1973.

Figure 2

FIRMS INVOLVED IN THE MANUFACTURE, DISTRIBUTION, AND INSTALLATION OF CONSTRUCTION MATERIALS


Manufacture
Distribution
Installation
Steel Mills & Fabricators
Aluminum Mills & Fabricators
Metals (7,900)
Forest Products Companies
Insulation Manufacturers
Floor Tile Manufacturers
Lumber, Construction Materials (13,600)
Electrical Products Manufacturers
Electrical Goods (13,500)
Pipe Manufacturers
Air Conditioning Equipment Manufacturers
Hardware, Plumbing Heating Equipment (16,700)
Asphaltic Concrete Hot-Mix (4,500)
Portland Cement Concrete Ready-Mix (10,000)
CONTRACTORS AND SUBCONTRACTORS (795,000)

Note: Numbers in parentheses are the numbers of firms in particular categories as of 1967.

Source: U.S. Department of Commerce Statistical Abstract, 1973.

construction but also for the automotive and railroad industries. These manufacturers, besides selling materials directly to contractors (usually for large purchases, shown by dotted line in Figure 2), have an established distribution network.

Most construction materials are sold through this network, which consists of four major types of wholesale distributors: metal; lumber and construction materials; electrical goods; and hardware, plumbing, and heating equipment. On the other hand, the two major construction materials that are not sold through distributors are hot-mix asphaltic concrete and ready-mix portland cement concrete. These materials are produced to meet local demands and are sold directly by the manufacturer to the builder. Including these asphalt and concrete producers, the number of construction materials distributors in the U.S. totals over 66,000.

FEDERAL SHARE OF CONSTRUCTION INDUSTRY

The Federal Government supports, through the activities of 18 agencies, a significant portion of the total annual new construction. As shown in Table 2, total federally supported construction in FY 1973 amounted to about $22.46 billion, or 18 percent of total U.S. new construction. There are important distinctions among the various categories of Federal construction:

- Direct - construction contracted directly by Federal agencies, (e.g., U.S. Army Corps of Engineers)
- Grants and loans (indirect) - the federal share of subsidized construction projects for state and local governments and private, nonprofit groups (e.g., the Environmental Protection Agency's contribution to local wastewater treatment facilities)
- Nonfederal share - that portion of a federally supported project financed by the state or local agency.

Thus, of the total of $22.46 billion, only $4.99 billion, or 22 percent, is direct construction, while indirect projects account for 78 percent of the total, or $17.47 billion. Later in the report, detailed breakdowns in terms of agencies and programs, facility types, and actual construction materials consumed are provided to show how these funds are spent. Some important distinctions between direct and indirect construction procurement will also be developed in relation to the feasibility of requiring recycled materials in construction products.

Table 2

Federal Construction Outlays - FY 1973*

	$ Billion	Percent
Federal Construction Funds:		
Direct	4.99	22
Grants and Loans	11.43	51
Total	16.42	73
Non-Federal Share of Grants and Loans	6.04	27
Total Federally Supported Construction	22.46	100
Total U.S. Construction (1972)	123.8	
Federal Share		18

*Sources: U.S. Dept. of Commerce, Statistical Abstract, 1973.

U.S. Office of Management and Budget, Special Analyses of the U.S. Government, FY 1974.

Resource Planning Associates estimates.

B. FEDERAL CONSTRUCTION PROCUREMENT PROCESS

To carry out its construction responsibility, the Federal Government has developed specific procurement processes. These processes reflect the various laws and regulations that govern Federal construction, as well as the government-established specifications that act as project controls. These three critical aspects - the procurement processes themselves, the relevant laws and regulations, and the specifications - are addressed separately in this section.

PROCUREMENT PROCESSES

There are two types of Federal procurement processes - direct and indirect.

Direct Procurement

Direct Federal construction projects are procured in exactly the same way as in the overall construction procurement process shown in Figure 1, with one exception: "Owner" becomes "Agency" (i.e., the Federal Government).

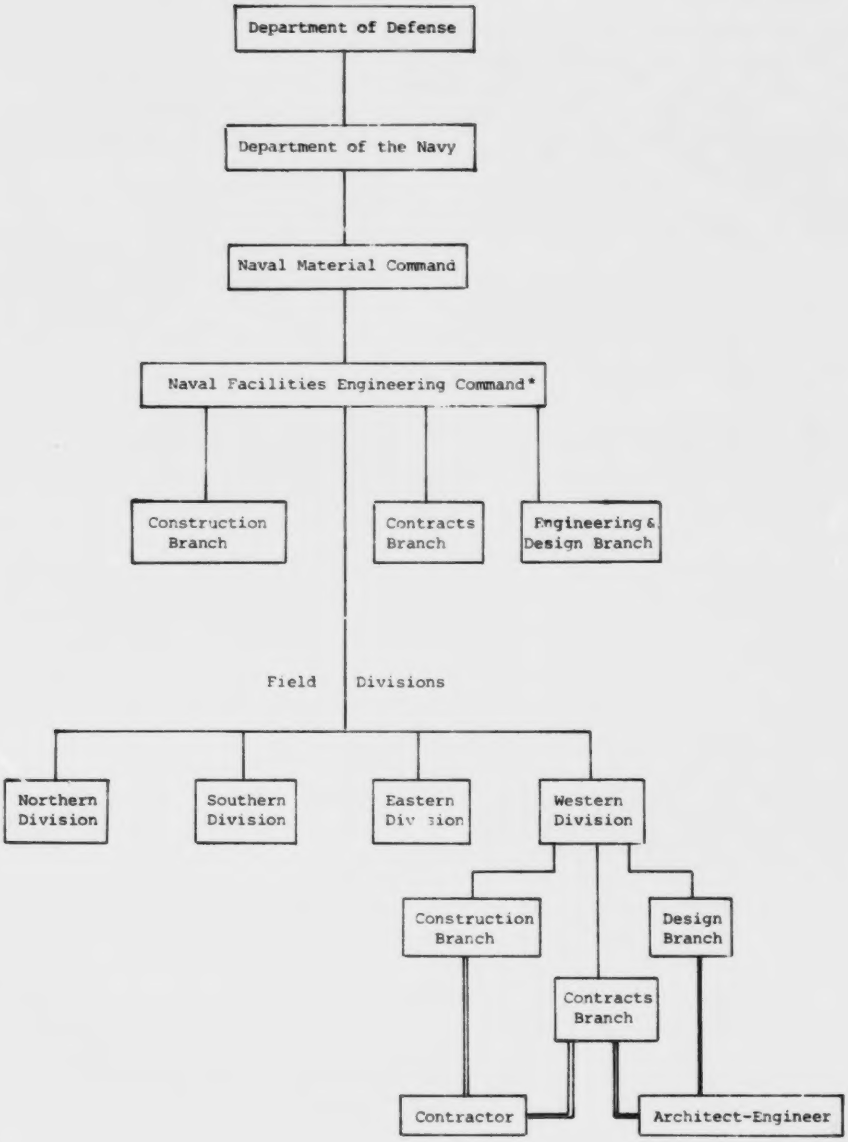
Although agencies vary in the way they organize and execute direct construction projects, there is a common organizational form that applies to most. (See Figure 3, which depicts the Department of the Navy's construction organization.) Most construction is decentralized - i.e., it is designed and built through one of four "field divisions" rather than by the headquarters group in Washington. Within each field division, there are three major offices, or branches:

- The Contracts Branch is responsible for contracts and other legal arrangements between the government and the A-E or the construction contractor.
- The Design Branch is responsible for accomplishing all design work, if the project is designed in-house; if the project is designed by an A-E, this branch is responsible for coordination and administration of the contract with the A-E.
- The Construction Branch is responsible for administration and coordination of the construction work as performed by the contractor.

The headquarters office also has these three branches. For special projects managed at this level, these branches function like their regional counterparts. When they do not have managerial

Figure 3

CONSTRUCTION ORGANIZATION - DEPARTMENT OF THE NAVY


Department of Defense
Department of the Navy
Naval Material Command
Naval Facilities Engineering Command*
Construction Branch
Contracts Branch
Engineering & Design Branch
Field Divisions
Northern Division
Southern Division
Eastern Division
Western Division
Construction Branch
Design Branch
Contracts Branch
Contractor
Architect-Engineer

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* The Naval Facilities Engineering Command is the organization within the Navy having overall responsibility for facilities construction and maintenance.

responsibility, they help establish policies and procedures to be followed by the regional offices, develop and monitor certain kinds of construction specifications and contractual requirements, and provide general assistance and guidance to the regional offices.

A typical project is executed in a series of steps in three phases, as follows:

Phase I - Predesign

1. Project funds are appropriated by Congress.

2. Regional Design Branch develops a broad description of project requirements, and establishes general design requirements.

Phase II - Design

3. If design is to be executed by an outside A-E, Contracts Branch develops A-E contract documents, including the general project requirements established in Step 2; solicits proposals from A-E firms; and selects firm based on fee and previous experience and reputation. If design is executed in-house, Design Branch develops construction plans and specifications.

4. A-E completes design, and develops a set of construction plans and specifications; these activities are administered by the Design Branch.

Phase III - Construction

5. Contracts Branch prepares construction contract bid documents consisting of the plans and specifications developed during the design phase; lets contract for bids to construction contractor; and awards contract to the lowest responsible bidder.

6. Contractor performs construction; activities are administered by the Construction Branch.

(Appendix A shows for each direct program the approximate percentage of projects which are designed by A-Es.)

Indirect Procurement

The process of indirect procurement differs from that for direct procurement in that the project is actually executed by the grant or loan recipient, who receives funding and some degree of guidance and control from the Federal agency. (See Figure 4.) The Department of Transportation's highway program, administered by the Federal Highway Administration (FHWA), is an example of an indirect construction procurement program. Here program administration, including funds allocation for particular projects, is totally decentralized, as it is accomplished by the state-level offices of the FHWA. Funds are annually allocated to the states from the Highway Trust Fund, and the state-level FHWA offices allocate the total funds pool to specific projects, upon review of project requests from the state highway departments. Having received project approval from the FHWA state representative, the state highway agencies then direct their design departments to prepare detailed project plans and specifications. When completed, these are submitted to the FHWA representative for final approval.

Upon approval, the state highway department then advertises for bids from highway construction contractors, and, as required by the FHWA, awards the construction contract to the lowest responsible bidder. The construction contract is administered by the state highway department, but FHWA representatives make periodic inspections to ensure the project is being accomplished in accordance with the approved plans and specifications.

LAWS AND REGULATIONS RELATED TO FEDERAL CONSTRUCTION PROCUREMENT

The direct and indirect procurement processes become operative through the laws that authorize the various agencies to procure construction, and the regulations that enable the agencies to implement their construction programs. The laws and regulations pertaining to both types of procurement are detailed in turn below.

Direct Procurement

The authority for direct construction procurement (other than the U.S. Postal Service*) is contained in two laws: The Federal Property and Administrative Services Act (FPASA), 410 U.S.C. 251; and the Armed Services Procurement Act (ASPA), 10 U.S.C. 2301. The basic requirement of the FPASA and ASPA, as related to construction (or to any Federal procurement for that matter) is that procurement must be competitive - i.e., except under certain conditions, goods and services must be

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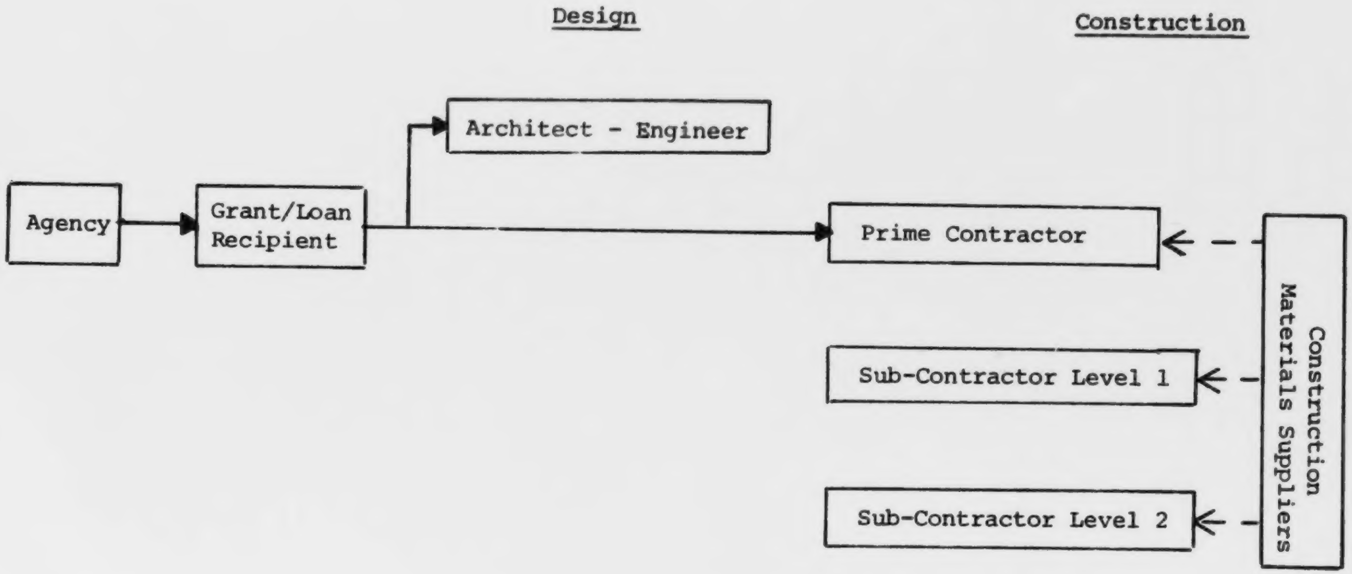
*Governed by the Postal Reorganization Act of 1971, 39 U.S.C. 410-A.

Figure 4

INDIRECT FEDERAL CONSTRUCTION PROCUREMENT PROCESS


Design
Construction
Agency
Grant/Loan Recipient
Architect - Engineer
Prime Contractor
Sub-Contractor Level 1
Sub-Contractor Level 2
Construction Materials Suppliers

procured at the lowest competitively bid cost. ASPA governs procurements of the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA): FPASA governs all other agencies, including the Army Corps of Engineers Civil Works construction activities.

Another category of laws that applies to most programs is the annual authorization and appropriations activities of Congress. Whereas the ASPA and FPASA provide the basic authority to procure construction, the annual appropriations acts provide the funding needed to accomplish the work.

Finally, the National Environmental Policy Act of 1969 requires that the Government prepare an environmental impact statement for "major Federal actions significantly affecting the quality of the human environment." Since most new direct construction projects are major federal actions that could significantly affect the environment, an environmental impact statement (EIS) is required for each such project.

The implementing regulations associated with FPASA and ASPA are the Federal Procurement Regulations (FPR), 41 CFR, and the Armed Services Procurement Regulations (ASPR), 32 CFR. Maintenance responsibility for these regulations is vested in the GSA and DOD, respectively.

All agencies governed by FPASA and ASPA are governed by FPR and ASPR, except the Tennessee Valley Authority, which has established its own regulations, and NASA and the Coast Guard, which are governed by both FPR and ASPR in their procurements. These regulations provide detailed instructions and guidance to agencies for all kinds of procurements, including construction. In accordance with the competitive procurement requirement contained in both laws, the regulations prohibit (except in unusual circumstances) the use of proprietary products. Proprietary specifications favor one manufacturer/supplier over another, and could result in a noncompetitive procurement.

Exceptions to the standard FPR and ASPR procurement requirements exist in the form of "mandatory" items (called "preference" items in ASPR). These result when legislative or Congressional action is taken explicitly to favor one product/service type or producer over another. Such action is taken only when it is deemed to be in the national interest. Examples of mandatory/preference items include:

- Buy American. Regulations require that American-made goods be used in domestic construction projects, where possible.

- Small Business Set-Asides. Regulations require that contracts below a certain funding level be awarded only to small businesses, which are defined as firms with annual sales less than a stated amount.

- Jewelled bearings. Where jewelled bearings are required as part of a procurement, they must be obtained from one particular producing facility.

- Aluminum stockpile. For a period of time, certain contracts involving the purchase of aluminum required that the aluminum be purchased from the Government stockpile.

In addition to the FPR and ASPR, more detailed implementing regulations are developed by each agency to govern specific types of procurements. For instance, in the Department of the Navy, there are two additional levels of regulations below the ASPR, which are more specifically related to the Navy's procurement of construction. These are Navy Procurement Directives (NPD), which govern all Department of the Navy procurements, and the Navy Contracts Manual (P-68), which is maintained by the Naval Facilities Engineering Command and covers all construction procurement procedures in detail.

Indirect Procurement

The legal and regulatory framework for indirect construction procurement is more complex than that for direct procurement. In the indirect procurement situation, there are different laws and regulations for each subsidy program because each is specifically authorized by Congress to meet some perceived national need, and each is directed at a specific type of recipient and type of facility. For example, the Watershed Protection and Flood Prevention Act authorizes the Department of Agriculture's Soil Conservation Service to provide funds in support of the Watershed Protection and Flood Control Program; and the Small Reclamation Projects Act allows the Department of the Interior's Bureau of Reclamation to provide funds for small irrigation loans. A complete list of the laws and regulations affecting each program is contained in Appendix A.

The regulations established to help each agency administer the law are contained in the Code of Federal Regulations. These regulations require competitive procurement, as do FPR and ASPR. Moreover, they focus on meeting program objectives (e.g., sewage treatment plant construction) rather than on conforming to strict detail with regard to purchase of goods and services. They usually allow the grant/loan recipient considerable purchasing freedom.

Lastly, like direct procurement, indirect procurement projects are required to submit an environmental impact statement.

SPECIFICATIONS FOR FEDERAL CONSTRUCTION PROJECTS

Specifications are used by the Federal Government to ensure construction spending results in cost-effective facilities that can be used for the purpose intended. These are the documents by which the government controls construction projects and the construction materials used therein. The various types of specifications that control direct and indirect procurement-type projects are discussed below.

Direct Procurement

There are three basic types of specifications used by government agencies in direct procurement situations:

- Contract specifications: A contract specification describes the facility to be built; the materials to be used; and, in some cases, how the facility is to be constructed. Each project has: (1) a set of plans that graphically show a detailed configuration of the proposed facility, and (2) a set of written specifications. The written specifications include general provisions, such as the Buy America requirements, and a technical section that describes each phase of the work in detail. The plans and the technical section of the specification are developed during the design phase - either in-house or by an outside A-E. The standard format for the technical section consists of 16 divisions, which are listed in Table 3.

  The construction materials used by the contractor on the job are controlled by this technical section. Materials are specified in two ways: by providing a detailed description of the material in regard to performance/technical requirements; or by referencing an existing material specification. The latter is described in detail in the section on material/product specifications. (It is of interest here to note that the general provision section, Standard Form 23-A, contains the following requirement under Section 9, Materials and Workmanship: "Unless otherwise specifically provided in the contract, all equipment, material, and articles incorporated in the work covered by this contract are to be new and of the most suitable grade for the purpose intended.")

- Guide specifications: Guide specifications play a key role in the procurement process because they provide guidance and direction to the A-E regarding the design of the facility. Since the A-E develops the detailed plans and specifications used by the contractor to construct the facility, the guide specification is a fundamental mechanism for the agency to control the end product. Appendix A lists the guide specifications used in each Federal construction program.

Guide specifications vary widely among agencies as to the level of detail in their requirements. However, most agencies with significant construction programs and with a major portion of design accomplished by outside A-Es maintain a sizable standard list of detailed guide specifications. An exception is the U.S. Postal Service, which uses outside A-Es on 100 percent of its design projects, yet has no guide specification for A-E control. The USPS maintains design criteria for the construction of postal facilities, which are general project requirements and not addressed to the details of design.

A number of agencies uses guide specifications that are grouped in sections corresponding to the 16 divisions of a standard construction contract. (See Table 3.) There is at least one guide specification in each of the 16 standard contract divisions, which the A-E uses as he prepares the plans and specifications. The "Naval Facilities Engineering Command Guide Specifications for Use in Regular Military Construction Projects" is provided in Appendix B as an example of federal guide specifications.

Guide specifications vary in their degree of specificity for construction materials. At one extreme, the guide specification may describe in detail the technical/performance requirements of the product. On the other hand, the guide specification may simply refer to one of many existing material specifications (either government-controlled or industry-wide); or, at the other extreme, the guide specification may leave the choice of materials entirely to the A-E. In the former two instances, the A-E would be required to include in the construction contract specification for a particular material either the technical requirements contained in the guide specification or a reference to the existing material specification listed in the guide specification.

An effort is currently under way, led by the Building Research Advisory Board and its Federal Construction Council, to standardize the guide specifications of federal construction agencies. They have established a Committee on Federal Construction Guide Specifications composed of representatives of the more than eight direct construction programs.

Table 3

Standard Construction Specification (Technical Section) Format

Division	Title
1	General Requirements
2	Site Work
3	Concrete
4	Masonry
5	Metals
6	Wood and Plastics
7	Thermal and Moisture Protection
8	Doors and Windows
9	Finishes
10	Specialties
11	Equipment
12	Furnishings
13	Special Construction
14	Conveying Systems
15	Mechanical
16	Electrical

These programs have guide specifications grouped according to the 16 technical divisions (Table 3), similar to the Naval Facilities Engineering Command specifications listed in Appendix B. Others include the Department of the Army; GSA; Department of Health, Education, and Welfare; NASA; and the Veterans Administration. Each of these programs has different guide specifications within each of the major technical divisions. The objective of the Committee is to standardize 144 of 165 guide specifications for all agencies; 40 have been completed to date.

- Material/product specifications: Material/product specifications are detailed, accurate descriptions of the technical requirements of particular items. The construction material specifications commonly used in Federal construction contracts are of two broad types - governmental and industrial.

  The primary governmental specifications include federal specifications and military specifications, under the cognizance of the GSA and the DoD, respectively. There are about 5,000 of the former and 40,000 of the latter,[6] covering a wide range of materials, many of which are not used in construction. Industry plays a significant role in the development of new governmental specifications. Every new specification is reviewed by a cross section of industry representatives, and revisions are made until the specification is satisfactory to the industry group.

  Although the governmental specifications are widely used, there is a developing trend toward the use of industry specifications for construction materials by certain agencies, such as the DoD and the U.S. Postal Service. Industry specifications are issued by a number of industrial groups, some covering a broad range of materials, others being very specialized in nature. The major specifications in the industrial category are those of the American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI).

  Most agencies engaged in construction procurement use established procedures to ensure compliance with the material specifications. This compliance is checked in two ways. First, the contractor is required to submit a written statement, certifying the materials to be used on the project conform to the specifications. Secondly, federal inspectors check the materials at the construction site to ensure the contractor's certified materials comply with contract requirements.

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[6] Arthur D. Little, Inc., Can Federal Procurement Practices Be Used to Reduce Solid Wastes, October 1973.

Indirect Procurement

Government agencies that administer grant and loan programs typically attempt to exert little or no influence over the construction materials used in the facilities for which they provide funds. Instead of detailed specifications, the agencies are likely to use "design guidelines," which provide general technical guidance and list general mandatory, project-performance requirements. (Appendix A lists each indirect construction program and the guidelines or guide specifications, if any, used. Also included is an assessment of the degree of control over construction materials that is embodied in the guidelines.)

An example is the EPA's "Federal Guidelines for Design, Operation, and Maintenance of Wastewater Treatment Facilities." Therein are listed requirements for the local government's preparation of project plans and specifications to be reviewed upon completion by the EPA's regional offices. The guidelines are oriented toward facility performance rather than toward the specific materials used in construction.

Although, as stated before, control is virtually nonexistent in most cases, there is at least one program that is quite specific in its requirements for construction materials used in subsidized projects. The Department of Agriculture's Rural Electrification Administration (REA) Bulletins 43-5 and 344-2 list acceptable construction materials for the REA's electric and telephone projects, respectively. Moreover, it is interesting to note that REA prohibits the use of recycled plastics in certain construction products used in supported facilities - specifically, REA Specification No. P-E-200 for polyethylene insulation for telephone cable requires that only virgin plastic resin be used in this material.

C. FEDERAL PROCUREMENT ANALYSIS

Because of the complexity of the Federal construction procurement processes, we have expanded on the base information by providing here relevant information on construction budgets of individual agencies, the types of facilities purchased, and the kinds and quantities of important construction materials used in such projects.

AGENCY CONSTRUCTION BUDGETS

The FY 1973 construction funding of 18 Federal departments and agencies, including the District of Columbia and the Architect of the Capitol, amounted to \$22.4 million, as shown in Table 4,* with indirect (grant/loan) programs accounting for \$17.4 million, or 78 percent, of the total. Agency funding ranged from \$12 million by the Department of Justice to \$8.3 billion by the Department of Transportation. Five of the 18 organizations are involved with both direct and indirect programs, while the remaining 13 focus exclusively on one type of program or the other - i.e., either direct or indirect.

The U.S. Army Corps of Engineers Civil Works Construction program is the largest of the direct programs, funded at over \$1.2 billion. (See Table 5.) Funded projects include dams, locks, floodwalls, power plants, and reservoirs. The Department of Defense is a close second, at \$1.1 billion, which supports a variety of military construction projects ranging from barracks to research laboratories. The Army's military construction program is administered by the Corps of Engineers Military Construction Directorate, while the Corps' civil works activities are managed by the Civil Works Directorate.

By far the most significant indirect federal construction program, in terms of funding, is the Department of Transportation's Federal-Aid Highway Program, administered by the Federal Highway Administration. (See Table 6.) Funded at over \$5.7 billion, this program represents over 25 percent of the cost of all new construction supported wholly or in part by the Federal Government. Funds are given to states under

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*Appendix A provides substantial additional information on the individual construction programs carried out by the organizations listed in Table 4. This information includes a description of the program, the funding level for FY 1973, important materials specifications used, the agency contact, and the estimated consumption of selected construction materials. In addition, for direct programs, it provides the percentage of design work contracted to outside A-Es; for indirect programs, it lists the laws authorizing the programs.

Table 4

Federal Construction Funding - FY 1973*

($ Million)

Department/Agency	Direct Construction (1)	Indirect Construction		Total Construction	
		Federal Share (2)	Total (3)	Federal[1] Share	Total[1]
Architect of the Capitol	33	-	-	33	33
Department of Agriculture	201	1,614	2,182	1,815	2,383
U.S. Army Corps of Engineers - Civil Works	1,221	-	-	1,221	1,221
Department of Commerce	-	220	376	220	376
Department of Health, Education, and Welfare	45	821	2,855	866	2,900
Department of Housing and Urban Development	-	1,167	1,533	1,167	1,533
Department of Interior	609	168	293	777	902
Department of Justice	1	8	11	9	12
Department of Transportation	311	5,741	7,996	6,052	8,307
District of Columbia	-	94	94	94	94
Environmental Protection Agency	-	1,600	2,133	1,600	2,133
General Services Administration	279	-	-	279	279
National Aeronautics and Space Administration	58	-	-	58	58
Veterans Administration	83	-	-	83	83
Postal Service	250	-	-	250	250
Tennessee Valley Authority	522	-	-	522	522
Atomic Energy Commission	237	-	-	237	237
Department of Defense	1,139	-	-	1,139	1,139
Total	4,989	11,433	17,473	16,422	22,462

[1] Federal Share = (1) + (2)
Total = (1) + (3)

* Source: U.S. Office of Management and Budget, Special Analyses of the U.S. Government, FY 1973.

RPA estimates.

Table 5

Summary of Major Direct Programs - FY 1973*

Department/Agency	Funding ($ MM)	Program Description
U.S. Army Corps of Engineers	1,221	Civil works facilities - flood control, navigation, power plants
Department of Defense		
Army	556	Military construction for all 3 department - housing, offices, hospitals, schools
Navy	306	
Air Force	277	
Department of the Interior		
Bureau of Reclamation	380	Irrigation projects, dams
Bureau of Indian Affairs	91	Schools, roads
Bonneville Power Administration	85	Power generation facilities
National Park Service	53	Recreation facilities
Tennessee Valley Authority	522	Power generation and transmission
General Services Administration	279	Federal Office buildings
Postal Service	250	Postal facilities--offices, warehouses
Total Major Programs	4,020 = 81% of all direct funding	

* Source: U.S. Office of Management and Budget, Special Analyses of the U.S. Government, FY 1973

Table 6

Summary of Major Indirect Programs - FY 1973*

Department/Agency	Funding ($ MM)[1]	Program Description
Department of Transportation		
Federal Highway Administration	5,782	Interstate/state highway grants
Urban Mass Transportation Administration	1,688	Mass transportation facilities grants; trackage, maintenance shops
Federal Aviation Administration	526	Airport facilities grants
Department of Health, Education, and Welfare		
Office of Education	1,428	Grants and loan subsidies for educational facilities
Hill-Burton	1,191	Grants and loans for hospitals
Health Professions	149	Grants for training facilities
National Institutes of Health	44	Grants for cancer research facilities
Nursing Profession	43	Grants for training facilities
Department of Agriculture		
Rural Electrification Administration	1,270	Rural electric and telephone facilities loans
Farmers Home Administration	754	Rural waste disposal facilities grants and loans
Soil Conservation Service	158	Flood prevention facilities grants and loans
Environmental Protection Agency	2,133	Municipal waste water collection/treatment facilities grants
Department of Housing and Urban Development		
Public Housing	900	Low-rent public housing facilities loans
Water/Sewer	439	Grants for water supply, sewage disposal facilities
Neighborhood Facilities	80	Grants for neighborhood facilities
Public Facilities	64	Loans for public facilities
College Housing	50	Loans for college housing
Total Major Programs	16,699 = 96% of all indirect funding	

[1] Funding = Total Federal and Non-Federal Share

* Source: U.S. Office of Management and Budget, Special Analyses of the U.S. Government, FY 1973.
RPA estimates.

formula grants to support the construction of interstate and primary highways and associated facilities, such as bridges and culverts.

With the exception of the EPA, the major agencies with indirect programs have at least three distinct programs to manage. The Department of Health, Education, and Welfare, which ranks second to the Department of Transportation with $2.8 billion, has five separate programs dealing with health or education facilities. The smallest, Nursing Professions, is only $43 million, whereas the Office of Education administers a $1.4 billion program of financial assistance to educational institutions.

FACILITIES FUNDED BY THE FEDERAL GOVERNMENT

An analysis of the programs described earlier and in Appendix A shows that, although there are about 40 separate direct and indirect programs, there are only 14 types of facilities included in federally supported projects.* (See Tables 7 and 8.) For convenience the facilities have been divided into two groups - buildings and nonbuildings. Of the indirect funding projects, the most heavily funded building types are hospitals, technical facilities, and schools, while the primary nonbuilding facilities are highways and sewage treatment plants. (See Table 8.) For directly funded projects, the most heavily funded types are military construction projects, which cover seven different facility types, the most prominent of which is housing. (See Table 7.)

CONSTRUCTION MATERIALS

Classification of federal construction funding by facility type provides the basis for understanding the kinds and quantities of construction materials purchased by the Government. Table 9 is an estimate of construction material consumption in FY 1973 for each of the facility types described above.

The 23 materials listed in Table 9, while not exhaustive in scope, represent a significant fraction of all building materials commonly used in construction today. Some materials are described in terms of square footage rather than tonnage (e.g., wall and floor coverings). The diversity of wall and floor covering materials, including insulation, makes it impossible to provide a meaningful estimate of material weight. Thus, square footage is the only logical measure.

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*Projects such as dredging, which use negligible quantities of construction materials, are excluded.

Table 7

Direct Project Funding by Facility Type - FY 1973*

($ Million)

Department/Agency / Facility Type	Architect of the Capitol	Department of Agri-culture	Corps of Engineers Civil Works	Department of Health, Education, and Welfare	Department of the Interior	Department of Justice	Department of Transportation	General Services Administration	National Aeronautics and Space Administration	Veterans Administration	Postal Service	Tennessee Valley Authority	Atomic Energy Commission	Department of Defense	Total Direct
Building Type Facilities															
Administrative	33	2				1	9	279			250			101	675
Hospitals Research, Other Technical		2		45			197		58	83			237	178	800
Schools					51		9							127	187
Industrial							12							175	187
Housing							10							363	373
Non-Building Type Facilities															
Subways, Railroad							20								20
Highways, Runways		163													163
Dams			170		270										440
Locks			134												134
Floodwalls			171												171
Power Plants			200		191							522			913
Sewage Treatment (including collection)		28													28
Electrical, Telephone Distribution							6							97	103
Water, Sewer Distribution					40		5							98	143
Total	33	195	675	45	552	1	268	279	58	83	250	522	237	1,139	4,337

Note: Excluded from totals are projects requiring negligible construction materials, e.g., dredging-totaling $652 MM.

***Source:** RPA estimates.

Table 8

Indirect Project Funding by Facility Type - FY 1973*

($ Million)

Facility Type \ Department/Agency	Department of Agriculture	Department of Commerce	Department of Health, Education, and Welfare	Department of Housing and Urban Development	Department of the Interior	Department of Justice	Department of Transportation	District of Columbia	Environmental Protection Agency	Total Indirect	Total Direct and Indirect
Building Type Facilities											
Administrative		113		80	18	11				222	897
Hospitals Research, Other Technical			1,235							1,235	2,035
Schools			1,620					42		1,662	1,849
Industrial							558			558	745
Housing				950						950	1,323
Non Building Type Facilities											
Subways, Railroads							1,130	38		1,168	1,188
Highways, Runways							6,045	14		6,059	6,222
Dams											440
Locks											134
Floodwalls											171
Power Plants											913
Sewage Treatment (including collection)	754								2,133	2,887	2,915
Electrical, Telephone Distribution	1,270									1,270	1,373
Water, Sewer Distribution		263		503	25					791	934
Total	2,024	376	2,855	1,533	43	11	7,733	94	2,133	16,802	21,139

Note: Excluded from totals are projects requiring negligible construction materials, e.g., reservoirs - totaling $671 MM.

*Source: RPA estimates.

Table 9

Construction Material Consumption by Facility Type - FY 1973*

Facility Type / Construction Material	Building Type Facilities					Non-Building Type Facilities									
	Administrative	Hospitals, Research, Other Technical	Schools	Industrial	Housing	Subways, Railroads	Highways, Runways	Dams	Locks	Floodwalls	Power Plants	Sewage Treatment (incl. collection)	Electrical, Telephone Distribution	Water, Sewer Distribution	Total
Portland Cement Concrete (000 tons)	2,200	3,400	4,300	4,200	2,300	130	21,000	8,800	5,100	800	4,000	1,300			57,530
Bituminous Concrete (000 tons)							39,000								39,000
Masonry (000 tons)															
Concrete Block	480	760	910	400	320										2,870
Brick	230	400	460		440										1,530
Steel (000 tons)															
Structural		120	240	230	70	50	340	130	70			70			1,320
Reinforcing	90	80	170	70	60	20	330	30	20		200	20			1,090
Miscellaneous							220								220
Flat Glass (000 tons)	34	40	38	16	40										168
Waterproofing (MMSF=million square feet)	16	20	62	54	29										181
Insulation (MMSF)	16	20	62	40	29										167
Roofing (MMSF)	16	20	62	54	17										169
Wall Covering (MMSF)	87	130	181	62	164										624
Floor Covering (MMSF)	36	51	73		60										220
Wire (000 tons)															
Copper	0.4	0.7	0.4	0.4	0.7								15		17.6
Aluminum													39		39
Insulation-Plastic													12		12
Pipe (000 tons)															
Cast Iron	6	30	22	3	10		30							220	321
Concrete							1,100					2,500			3,600
Clay							50					1,100		120	1,270
Copper	0.3	1.5	1.1	0.2	0.5										3.6
Asbestos-Cement												145			145
Plastic	0.3	1.3	0.9	0.1	0.4							15		14	32
Steel							60								60

*Source: RPA estimates.

Table 9 was developed primarily by using standard construction estimating techniques in conjunction with the facility cost information in Tables 7 and 8. Unfortunately, most federal agencies, with the exception of the Army Corps of Engineers (Civil Works), the Department of Transportation (highway program), and the Department of Agriculture (rural electification), do not maintain aggregate construction material consumption information. Thus, estimates were made on the basis of the best information available.

The information in Table 9 leads directly to estimates of construction material consumption by agency and program. Agency consumption information is provided in Tables 10 and 11 (direct and indirect programs, respectively), and estimates for individual programs are provided in Appendix A.

As indicated by the agency-funding breakdowns of Tables 4, 5, and 6, the major share of most materials is consumed by only a few agencies. Table 12 indicates that for direct programs, the Department of Defense (including both military construction and Corps of Engineers Civil Works) was the largest consumer for 17 of the 23 items listed. The share for individual materials ranged from 34 percent to 90 percent of the material consumed in direct programs.

Table 13 lists the four agencies that were the largest purchasers of 21 of the 23 materials in the indirect program area: Department of Transportation - structural materials (i.e., concrete and steel); Department of Health, Education, and Welfare - building materials (i.e., insulation, masonry, roofing); Department of Agriculture - electrical products (i.e., wire and insulation); and Environmental Protection Agency - sewer pipe.

Table 10

Construction Material Consumption by Agency - Direct Programs - FY 1973*

Agency / Construction Material	Architect of Capitol	Department of Agriculture	Corps of Engineers Civil Works	Department of Health, Education & Welfare	Department of Interior	Department of Transportation	General Services Administration	National Aeronautics & Space Administration	Veterans Admin.	Postal Service	Tennessee Valley Authority	Atomic Energy Commission	Department of Defense	Total Direct
Portland Cement Concrete (000 tons)	88	643	10,372	68	6,457	437	682	102	136	616	2,000	408	2,436	24,445
Bituminous Concrete (000 tons)		1,170												1,170
Masonry (000 tons)														
Concrete Block	19			15	27	84	149	23	30	134		91	363	935
Brick	9			8	14	42	71	12	16	64		48	215	499
Steel (000 tons)														
Structural		11	121	2	86	18		4	5			14	99	360
Reinforcing	4	10	84	2	71	10	27	2	3	25	100	10	60	408
Miscellaneous		6												6
Flat Glass (000 tons)	1.4			1	1.1	5	10.6	1	2	9.5		5	24.7	61.3
Waterproofing (MMSF= Million Sq. Ft.)	0.6			0.4	2	3.3	4.9	0.6	0.8	4.5		2.4	28.5	48
Insulation (MMSF)	0.6			0.4	2	3.1	4.9	0.6	0.8	4.5		2.4	25.7	45
Roofing (MMSF)	0.6			0.4	2	3.2	4.9	0.6	0.8	4.5		2.4	25.2	44.6
Wall Covering (MMSF)	3			3	5	15	28	4	5	24		16	92	195
Floor Covering (MMSF)	1.4			1	2	6.4	11.2	2	2	10		6	29	71
Wire (000 tons)														
Copper	0.016			0.01	0.012	0.282	0.124	0.02	0.03	0.112		0.08	1.614	2.30
Aluminum						0.4							2.8	3.2
Insulation Plastic						0.1							0.9	1.0
Pipe (000 tons)														
Cast Iron	0.24	1		0.5	9.7	4.92	1.86	0.9	1.2	1.68		3.6	30.45	56.15
Concrete		58												58
Clay		12			5	1							12	30
Copper	0.012			0.03	0.03	0.152	0.093	0.05	0.06	0.084		0.18	0.424	1.115
Asbestos-Cement		1												1
Plastic	0.012			0.03	0.63	0.229	0.093	0.04	0.05	0.084		0.16	1.764	3.092
Steel		2												2

*Source: RPA estimates.

Table 11

Construction Material Consumption by Agency - Indirect Programs - FY 1973*

Agency / Construction Material	Agriculture	Department of Commerce	Department of Health, Education and Welfare	Department of Housing and Urban Development	Department of Interior	Department of Justice	Department of Transportation	District of Columbia	Environmental Protection Agency	Total Indirect	Total Direct and and Indirect
Portland Cement Concrete (000 tons)	338	286	5,858	1,854	44	22	23,644	90	949	33,085	57,530
Bituminous Concrete (000 tons)							37,830			37,830	39,000
Masonry (000 tons)											
Concrete Block		62	1,266	274	10	5	300	18		1,935	2,870
Brick		30	648	337	5	2		9		1,031	1,530
Steel (000 tons)											
Structural	18		286	50			548	7	51	960	1,320
Reinforcing	5	12	198	52	2	1	392	5	15	682	1,090
Miscellaneous							214			220	
Flat Glass (000 tons)		4.4	56.5	31.9	0.7	0.3	12.1	0.8		106.7	168
Waterproofing (MMSF = million sq. ft.)		2.1	66.2	22.2	0.3	0.2	41	1		133	181
Insulation (MMSF)		2.1	66.2	22.2	0.3	0.2	30	1		122	167
Roofing (MMSF)		2.1	66.2	13.6	0.3	0.2	41	1		124.4	169
Wall Covering (MMSF)		11	237	126	2	1	48	4		429	624
Floor Covering (MMSF)		4.7	95	47.2	0.7	0.4		1		149	220
Wire (000 tons)											
Copper	13.6	0.052	0.792	0.536	0.008	0.004	0.3	0.008		15.3	17.6
Aluminum	35.8									35.8	39
Insulation - Plastic	11									11	12
Pipe (000 tons)											
Cast Iron		62.78	37.6	125.64	7.12	0.06	31.25	0.4		264.85	321
Concrete	650						1,067		1,825	3,542	3,600
Clay	286	34		64	4		49		803	1,240	1,270
Copper		0.039	1.88	0.387	0.006	0.003	0.15	0.02		2.485	3.6
Asbestos-Cement	38								106	144	145
Plastic	4	3.939	1.55	7.915	0.406	0.003	0.075	0.02	11	28.908	32
Steel							58			58	60

*Source: RPA estimates.

Table 12

Selected Department of Defense Construction Materials - FY 1973

Corps of Engineers - Civil Works

- Portland Cement Concrete - 10,372,000 tons, 42% of total direct consumption
- Structural Steel - 121,000 tons, 34%

Military Departments - Military Construction

- Concrete block masonry - 363,000 tons, 39%
- Brick Masonry - 215,000 tons, 43%
- Flat Glass - 24,700 tons, 40%
- Waterproofing - 28,500,000 square feet, 59%
- Insulation - 25,700,000 square feet, 57%
- Roofing - 25,200,000 square feet, 57%
- Wall Covering - 92,000,000 square feet, 47%
- Floor Covering - 29,000,000 square feet, 41%
- Copper Wire - 1,614 tons, 70%
- Aluminum Wire - 2,800 tons, 88%
- Plastic Insulation - 900 tons, 90%
- Cast Iron Pipe - 30,450 tons, 54%
- Clay Pipe - 12,000 tons, 40%
- Copper Pipe - 424 tons, 38%
- Plastic Pipe - 1,764 tons, 57%

Table 13

Selected Indirect Program Construction Materials - FY 1973

Department of Transportation

- Portland Cement Concrete - 23,644 tons, 71% of total indirect consumption
- Bituminous Concrete - 37,830,000 tons, 100%
- Structural Steel - 548,000 tons, 57%
- Reinforcing Steel - 392,000 tons, 57%
- Miscellaneous Steel - 214,000 tons, 97%
- Steel Pipe - 58,000 tons, 100%

Department of Health, Education and Welfare

- Concrete Block Masonry - 1,266,000 tons, 65%
- Brick Masonry - 648,000 tons, 63%
- Flat Glass - 56,500 tons, 53%
- Waterproofing - 66,200,000 square feet, 50%
- Insulation - 66,200,000 square feet, 54%
- Roofing - 66,200,000 square feet, 53%
- Wall Covering - 237,000,000 square feet, 55%
- Floor Covering - 95,000,000 square feet, 64%

Department of Agriculture

- Copper Wire - 13,600 tons, 89%
- Aluminum Wire - 35,800 tons, 100%
- Plastic Insulation - 11,000 tons, 100%

Environmental Protection Agency

- Concrete Pipe - 1,825,000 tons, 52%
- Clay Pipe - 803,000 tons, 65%
- Asbestos-Cement Pipe - 106,000 tons, 74%
- Plastic Pipe - 11,000 tons, 38%

D. FEDERAL ACTIVITIES RELATED TO PROCUREMENT OF SECONDARY MATERIALS

Several Federal agencies have developed programs to procure products containing recycled materials, or to conduct research and demonstration programs related to the use of recycled materials in certain product types. This section briefly discusses these programs.

GENERAL SERVICES ADMINISTRATION

In 1972 the Federal Supply Service (FSS) of GSA, at the direction of the President, reviewed all Federal specifications to determine which ones, if any, could be modified to require the use of recycled materials. FSS selected 86 specifications and established requirements for minimum percentages of recycled material for each. For 43 of these products, there exists a further requirement for a minimum percentage of post-consumer waste use.

Of the 86 specifications, six are for building materials:

- o Specifications HH-I-515-B, LLL-I-535A - Thermal Insulation
- o HH-I-1030 - Thermal Insulation (Mineral Fiber)
- o HH-R-595 B, SS-R-201 D, SS-R-630 D - Roofing Felts.

While conducting their specification review, GSA also identified a number of specifications that discriminated against recycled materials. Several of these were modified, not to require, but to allow the use of secondary materials. The following two building material specifications are in this category:

- o Specification L-P-315C - Plastic Pipe
- o Specification HHH-I-521 - Mineral Fiber Insulation.

The Federal Supply Service purchases products on a competitive-bid basis, in accordance with the requirements of the FPASA. Individual procurements often cover only one product type. The procurements are usually large enough to enable the government to deal directly with the producing mill rather than with distributors.

Several significant observations about the GSA procurement program were drawn from discussions with Federal Supply Service officials:

- Flexible specifications are important. If the recycle requirement of a particular procurement discourages producer mills from bidding, the Federal Supply Service is prepared to lower the percentage to a point acceptable to the mills.
- Some traditional government suppliers halted their federal transactions because of the recycle requirement either because of administrative complexity or because their operations were not geared to using recycled materials.
- During periods of high paperstock prices, GSA had to pay higher prices for paper with the mandatory recycle content than they would have otherwise. This created a conflict with the FPASA competitive bid requirement, and GSA waived the recycle requirement in certain cases.

In addition to the aforementioned procurement program of the Federal Supply Service, the Public Buildings Service of GSA is sponsoring an Environmental Demonstration Project in conjunction with a new federal office building in Saginaw, Michigan. Besides demonstrating energy-efficient building design concepts (e.g., the use of solar energy collectors), this project is utilizing three applications of waste material use in building products: (1) wall panels made from demolition rubble; (2) paving materials containing wastes; and (3) walkways containing waste brick.

OTHER R & D, DEMONSTRATION PROJECTS

Other Federal activities related to waste use in construction are:

- The Department of Transportation, which has experimented with using waste glass and rubber in pavement applications
- The Atomic Energy Commission, which has demonstrated, in a project at Brookhaven National Laboratory, polymer/concrete sewer pipe containing waste glass

- The Department of Commerce, National Bureau of Standards, which is conducting research in a number of product areas, and is maintaining liaison with international standards organizations to ensure up-to-date information transfer in this area.

* * *

In summary, then, our analysis of the feasibility of required secondary material use in Federal construction shows that:

- The construction contracting industry is extremely fragmented - 800,000 firms, most of which are small businesses.
- The construction materials industry cuts across industry lines, involving many types of product manufacturers and over 66,000 distributors.
- The Federal Government purchases or supports a major share of national construction output - 18 percent, or $22.5 billion.
- Construction materials are not purchased directly by the government, but rather by the contractors and subcontractors, who install the materials.
- Direct procurement accounts for only 22 percent of federally supported construction; indirect procurement (grants and loans to state and local governments) represents the remaining 73 percent.
- Most indirect programs currently have no requirements related to construction materials since local authorities have design and specification authority.
- By law, construction procurement must be competitive.
- Federal construction is administered by 18 separate agencies and departments, which means there is no centralized procurement control.
- The majority of construction funding and materials purchases is concentrated in a small group of agencies:

- Direct: Department of Defense, including Army Corps of Engineers, Civil Works Directorate

- Indirect: Department of Transportation; Department of Health, Education, and Welfare; Department of Agriculture; and Environmental Protection Agency.

On the basis of the fact-finding summarized above, three general conclusions* can be drawn:

1. Guide specifications and/or material specifications for direct programs can be modified to include a recycle content requirement, similar to GSA's program.

2. For indirect programs, although the laws do not appear to preclude the imposition of construction material requirements on grant/loan recipients, the present general reluctance to impose material requirements is a significant institutional barrier to required recycled material use.

3. The government's indirect control over material suppliers, through contruction contractors and sub-contractors, would result in less leverage and greater administrative complexity than experienced by GSA in its recycled paper program.

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*Specific conclusions are included in the waste material/construction product discussions in Chapter III.

III. OPPORTUNITIES TO USE WASTES IN CONSTRUCTION MATERIALS

Given the government's apparent willingness to use recycled materials in its construction projects, it is imperative to consider what post-consumer wastes lend themselves to recovery for usage in construction. materials. We have considered four municipal waste categories: ferrous, glass, plastics, and paper. Each of these four sections is structured as follows:

1. Identification of construction products that are or could be made from these materials, including an assessment of current scrap usage in existing products
2. Analysis of the supply of waste that might be available for use in the products, including the economics and technology of resource recovery
3. Assessment of the opportunities for additional waste utilization in selected products, including both the technical limits to recycling, and the associated industry impacts and institutional constraints
4. Analysis of the potential impacts on the waste stream of Federal procurement of selected products

A. IRON AND STEEL

USES OF IRON AND STEEL IN CONSTRUCTION

After the automobile industry, construction is the largest user of iron and steel products, utilizing 22 percent of total steel shipments and 20 percent of total cast iron shipments. (See Table 14.) Specifically, of the total 1973 iron and steel shipments of 126.73 million tons, 24.40 million tons were used in construction materials.

Of the major iron and steel construction product categories, structural and sheet steel account for 65 percent of the steel construction products manufactured in 1973. (See Table 15.) Bars, primarily concrete reinforcing steel, account for 14 percent of steel construction products, and pipe is by far the most significant cast iron construction product.

Table 14

Iron and Steel Markets - 1973*

	Shipments (MM Tons)	Percent of Steel Shipments
Steel		
Automotive	30.01	27
Construction	24.40	22
Containers, Packaging	10.07	9
Machinery, Industrial Equipment	8.13	7
Converting, Processing	6.00	5
Electrical Equipment	4.32	4
Rail Transportation	4.20	4
Other	24.30	22
Total Shipments	111.43	100
		Percent of Cast Iron Shipments
Cast Iron		
Construction/Pipe	3.0	20
Other	12.3	80
Total Shipments	15.3	100
Total Steel and Iron	126.73	

*Source: American Iron and Steel Institute, Annual Statistical Report for 1973.

Resource Planning Associates estimates.

U.S. Department of Commerce, Statistical Abstract, 1973.

Table 15

Iron and Steel in Building/Construction - 1973*

	Shipments (MM Tons)	Percent
Steel		
Structural shapes, plates, piling	8.54	35
Sheet	7.37	30
Bars (reinforcing and other)	3.42	14
Pipe	3.19	13
Other	1.88	8
Total	24.40	100
Cast Iron		
Pipe	3.0	100
Total Steel and Iron Used in Construction	27.40	

*Source: American Iron and Steel Institute, Annual Statistical Report for 1973.

Resource Planning Associates estimates.

U.S. Department of Commerce, Statistical Abstract, 1973.

Various kinds and quantities of scrap can be used in iron and steel construction products. (See Table 16.) Total scrap content in the various construction products ranges from 41 percent (in sheet, steel pipe) to 95 percent (in bars); obsolete scrap content ranges from 2 percent to 42 percent. For all products, obsolete scrap use amounted to 3.01 million tons, or 11 percent of total iron and steel construction materials produced.

This variation in scrap use among products is explained by two factors:

1. Technical requirements of the product. For example, concrete reinforcing bars have low technical/performance specifications and are therefore less dependent on high-quality scrap or iron ore than, for instance, sheet steel.

2. The manufacturing process involved. The three major steel-making processes are: basic-oxygen furnace, open-hearth furnace, and electric furnace, accounting for 50 percent, 30 percent, and 20 percent of total U.S. steel production, respectively.

   Basic-oxygen and open-hearth steelmaking furnaces are used by large, integrated steel companies in conjunction with blast furnaces, which produce pig iron from iron ore. The pig iron from the blast furnace is mixed with a percentage of scrap in the steelmaking furnace to produce steel. A number of the integrated producers also use electric furnaces in addition to one or both of the other types. However, most electric-furnace production comes from nonintegrated mills, which use the electric furnace exclusively.

   The average scrap input for these three furnace types is 30 percent for basic-oxygen furnaces, 45 percent for open-hearth furnaces, and 100 percent for electric furnaces. The first two percentages do not represent the upper limit of scrap that could be used in the steel-making process. Rather, they result from a complex combination of technical, economic, and institutional factors associated with integrated steel manufacture. For instance, the ready availability of pig iron from the blast furnace tends to limit scrap consumption, particularly during times of high scrap prices.

   Most cast iron is produced in cupola furnaces. The foundry cupola, like the electric furnace, typically operates with a scrap charge approaching 100 percent,

Table 16

Scrap Use in Iron and Steel Construction Products - 1973*

	Shipments (MM Tons)	Home & Prompt Scrap		Obsolete Scrap		Total Scrap Content	
		Percent	MM Tons	Percent	MM Tons	Percent	MM Tons
Steel							
Sheets	7.37	39	2.87	2	0.15	41	3.02
Structural shapes, plates, piling	8.54	41	3.50	6	0.51	47	4.01
Bars (reinforcing and other)	3.42	53	1.81	42	1.44	95	3.25
Pipe	3.19	39	1.24	2	0.06	41	1.30
Other	1.88	39	0.73	2	0.04	41	0.77
Total	24.40	42	10.15	9	2.20	51	12.35
Cast Iron							
Pipe	3.0	58	1.74	27	0.81	85	2.55
Total Steel & Iron Used in Construction	27.40	43	11.89	11	3.01	54	14.90

*Source: Resource Planning Associates estimates.

American Iron and Steel Institute, Statistics Department.

Communication with Industry Representatives.

Jensen, Harold B., Analysis of Ferrous Scrap Supply-Demand Balance, U.S.A., 1973.

thus explaining the high 85-percent scrap consumption for cast iron pipe. (See Table 16.)

With the exception of bars, the steel products listed in Table 16 are manufactured predominantly by the integrated producers, in either the basic-oxygen or open-hearth furnace. Bars, on the other hand, are made primarily in electric furnaces. (See Table 17.) This explains the variations in total scrap consumption percentages for the products listed in Table 16. It also helps to explain the variation in obsolete scrap consumption for the products. The integrated producer has little need to use obsolete scrap since, with a total scrap charge of 30-45 percent and a typical home scrap generation rate of 30 percent, the balance of scrap requirements - if any - can be made up from prompt industrial sources. Therefore, most of the obsolete scrap flows to the foundries and nonintegrated electric mills.

SUPPLY OF OBSOLETE FERROUS SCRAP

Before one can consider the possibility of using greater amounts of obsolete scrap in iron and steel construction products, it is first necessary to consider the types and quantities of obsolete scrap that might be available.

There are eight types of scrap potentially available from municipal and nonmunicipal sources. (See Table 18.) Of the total 43 million tons of scrap from these eight sources, 11.03 million tons (26 percent) are municipal scrap, and 31.97 million tons (74 percent) are nonmunicipal scrap.

Most nonmunicipal scrap is currently being recycled back to the steel mills through established networks of salvage firms, auto wreckers, demolition contractors, and scrap dealers. (See Table 19 for typical chemical composition of this type of material.) However, most municipal ferrous scrap is not being recycled; rather, it is dumped into landfills, along with the rest of the country's municipal wastes and garbage.

A portion of this wasted municipal scrap could indeed become available for recycling. In particular, the beverage containers and other packaging categories (i.e., ferrous cans) are the most readily

Table 17

Breakdown of Production Processes for Steel Construction Products*

	Integrated Mills		Non-Integrated Mills
	BOF/Open Hearth	Electric	Electric
Structural	81%	9%	10%
Bars	10	25	65
Sheets, pipe, other	90	10	-

*Source: Communication with Industry Representatives.
Resource Planning Associates estimates.

Table 18

Obsolete Iron and Steel Scrap Sources - 1973*

	MM Tons	
Nonmunicipal		
Junk Cars	8.31	
Motor Blocks	1.60	
Railroad Scrap	2.56	
Ship Scrap	0.64	
Other	18.86	
Total	31.97	(74%)
Municipal		
Beverage Containers	1.87	
Other Packaging	3.75	
Appliances and Other	5.41	
Total	11.03	(26%)
Total Nonmunicipal and Municipal Yield	43.00	

*Source: Jensen, Harold B., Analysis of Ferrous Scrap Supply-Demand Balance, U.S.A., 1973.

Skinner, Dr. John, "Resource Recovery: The Federal Perspective," Waste Age, January/Feb., 1974, pg. 14.

Table 19

Composition of No. 2 Bundles and Burned Slab*

(Percent by Weight)

	No. 2 Bundle	Burned Slab
Carbon	0.16	0.28
Sulfur	0.048	0.070
Manganese	0.10	0.12
Phosphorous	0.012	0.015
Tin	0.038	-
Copper	0.38	0.41
Chromium	0.10	0.17
Nickel	0.08	-
Molybdenum	0.02	-
Silicon	0.06	0.01

*Source: Ostrowski, Ed, The Bright Outlook for Recycling Ferrous Scrap from Solid Waste, 1974.

recyclable materials.* Approximately 35 percent of beverage containers are made from tin-free steel, while all nonbeverage containers contain tin. Thus, approximately 89 percent of all ferrous containers have some tin content. These cans also contain some lead, since they are constructed with a lead-solder side seam. Most beverage containers have aluminum ends; hence, about 33 percent of ferrous containers have some aluminum content as well. The average percent in an average mix of clean ferrous cans (as might be recovered with a source-separation program), by weight, of aluminum is 3.4; of tin, 0.4; and of lead, 1.7.[7]

Aside from clean, separated cans, municipal ferrous scrap may also be available from front-end-separated scrap (obtained through a resource-recovery system) and incinerator residue. This ferrous waste would include both can and "other" ferrous materials. (Typical compositions of these materials are shown in Table 20.)

For nonincinerated municipal ferrous waste, an important market prior to the steel mill is the de-tinner, which removes the tin and sends the remainder to the mill. This is an important factor since high tin content of scrap may adversely affect certain steel properties, such as ductility.

POTENTIAL FOR OBSOLETE SCRAP USE

The use of low-grade scrap in the manufacture of iron and steel products has various degrees of acceptability. (See Table 21.) Although this acceptance is a qualitative assessment, based on a general understanding of the product types and their technical performance requirements, it appears the most advantageous opportunities to use obsolete scrap are in:

> Bars. The major industry specification used by the Government and most other construction contracting groups for bars is the ASTM Specification A615-72, Standard Specification for Deformed and Plain Billet - Steel Bars for Concrete Reinforcement. In the event the specification would require minimum municipal scrap content, industry would probably not meet the requirement. Specifically, since only

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*The appliances and other category contains items that are often contaminated with nonferrous metals, plastics, or other materials, and are therefore more difficult to recycle.

[7] Ostrowski, E. J., "Recycling of Tin-Free Steel Cans, Tin Cans and Scrap from Municipal Incinerator Residue," 1971.

Table 20

Composition of Front-End-Separated And Incinerator Residue Ferrous Scrap*

(Percent by Weight)

	Incinerator Residue	Front-End Separated
Carbon	0.047	0.30
Sulfur	0.047	0.013
Manganese	0.027	0.30
Phosphorous	0.034	0.024
Tin	0.223	0.165
Copper	0.360	0.06
Chromium	0.028	0.089
Nickel	0.054	0.045
Molybdenum	0.020	0.024
Aluminum	-	0.089
Lead	0.019	0.129

*Source: Ostrowski, Ed, The Bright Outlook for Recycling Ferrous Scrap from Solid Waste, 1974.

Table 21

Acceptability of Low-Grade Scrap Use In Iron and Steel Construction Products*

Steel	
Bars (reinforcing and other)	Excellent
Structural shapes, plates, piling	Good/Fair
Sheets	Marginal/Unsuitable
Pipe	Marginal/Unsuitable
Other	Marginal/Unsuitable
Cast Iron	
Pipe	Good

*Source: Midwest Research Institute, An Evaluation of Means to Stimulate Scrap by the Iron and Steel Industry, 1971.

Resource Planning Associates estimates.

35 percent of all bars are produced in integrated mills, and since bars typically account for less than 10 percent of an integrated mill's output, the integrated mills would probably not produce to the specification requirement. The potential for contamination of higher grade steels and the integrated producer's traditional reliance on high-quality scrap are major constraints. Both factors would probably keep integrated producers from using municipal scrap, until the demand grew to a significant portion of the market. The nonintegrated electric mills, while evidencing some concern about the impurities and other technical problems associated with municipal scrap, would be expected to produce to the specification, given access to a sufficient supply of scrap.

Structural shapes, plates, and piling. The major specifications are ASTM Specifications A36-70a, A529-72, and A440-70a, Standard Specifications for Structural Steel, Structural Steel with 42,000 psi Yield Point, and High Strength Structural Steel, respectively. It is expected that a specification requirement for structural steel to contain, say, 12-percent municipal ferrous scrap would meet with strong resistance from firms operating the basic-oxygen furnace, which consumes 30 percent scrap, and generates approximately 30 percent home scrap, thereby creating very little need for any imported scrap.

The open-hearth producers would be more willing to comply with the specification. Nevertheless, there would be some resistance because of concern about possible contamination of higher grade steels and traditional reliance on higher quality scrap. Again, the nonintegrated electric mills would be most responsive to the specifications, but the impact of these mills would be small since they account for only 10 percent of total structural steel production. (See Table 17.)

Cast iron pipe. The specification relied on for cast iron pipe is the ANSI Standard A21.51, Ductile-Iron Pipe. Should a minimum municipal scrap content requirement evolve, it is likely industry response would be similar to that of the nonintegrated electric mills for the bar specification - favorable, with reservations about scrap impurities and other technical problems.

The above-indicated specifications and standards contain both material composition and technical performance requirements. The performance requirements relate primarily to tensile strength and ductility; chemical composition requirements are shown in Table 22.

Table 22

Chemical Composition Requirements for Selected Iron and Steel Construction Products

(Percent by Weight)

	Bars ASTM A 615-72	Structural			Ductile Iron Pipe ANSI A21.51[1]
		ASTM A36-70a	ASTM A529-72	ASTM A440-70a	
Carbon, max.	-	0.26	0.27	0.28	(0.27)
Manganese, max.	-	-	1.20	1.10-1.60	(1.20)
Phosphorous, max.	0.05	0.04	0.04	0.04	(0.10)
Sulfur, max.	-	0.05	0.05	0.05	(0.10)
Silicon, max.	-	-	-	0.30	(0.30)
Copper, min, when copper is specified	-	0.20[2]	0.20[2]	0.20[2]	(0.35)

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[1] ANSI A21.51 does not specify composition requirements. Numbers listed are from an industry source.

[2] Industry sources state that 0.35 is a safe maximum copper limit

In addition to the elements listed in Table 22, steel mill operators are concerned with other materials, especially those found in municipal ferrous scrap. Tin is a major concern because of its adverse impact on the ductility of steel. It appears that a maximum tin concentration of 0.2 percent would be acceptable for bars, and 0.1 percent* would be acceptable for structural steel and ductile iron pipe.

Lead and aluminum are also important to the manufacturers, not because of their impact on the quality of the steel product, but because of the potential for adverse impact on the manufacturing process. For example, lead, though it oxidizes to lead oxide in the basic-oxygen furnace, does not oxidize in other furnace types, thereby causing problems with refractory materials. Aluminum in significant quantities causes a rather violent exothermic reaction in the steel-making furnace, and causes changes in slag composition, which may adversely affect the refractories. When continuous casting is employed, aluminum can cause problems by clogging the nozzles used in this process.

Since lead and aluminum do not affect steel properties, they will not be considered in determining the technical limits of obsolete scrap use for the various steel products. However, they will be discussed more fully later in the report, where other technical and economic issues that bear on the problem are examined.

Table 23 summarizes the chemical composition of the obsolete scrap types in Tables 19 and 20, with emphasis on those critical trace elements described above. Also shown in Table 23 are those instances in which the scrap contains elements in excess of the product limits.

Clearly, each source of scrap contains elements that exceed specification limits for at least one product type; key contaminants are tin, copper, carbon, and phosphorus. This means that a 100-percent obsolete scrap charge would probably result in a nonconforming product output. Thus it is important to know the technical limits of scrap input for the specific products.

The maximum technical limits of the various sources of obsolete scrap for the three selected products, assuming 100 percent of the scrap impurities are transferred to the steel product, are shown in Table 24. Specifically, the tin content of source-separated cans limits their maximum scrap charge to 25-50 percent, whereas the other

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*Based on information obtained from industry representatives.

Table 23

Composition (Selected Elements) of Various Types of Obsolete Scrap

(Percent by Weight)

	Municipal			Non-Municipal	
	Source-Separated Ferrous Cans	Incinerator Residue	Front-End Separated	No. 2 Bundle	Burned Slab
Tin	$0.40^{1,2,3}$	$0.223^{1,2,3}$	$0.165^{2,3}$	0.038	-
Carbon	-	0.047	$0.30^{2,3}$	0.16	$0.28^{2,3}$
Manganese	-	0.027	0.30	0.10	0.12
Phosphorous	-	0.034	0.024	0.012	0.015
Sulfur	-	0.047	0.013	0.048	0.070^{2}
Silicon	-	-	-	0.06	0.01
Copper	-	$0.360^{2,3}$	0.06	$0.38^{2,3}$	$0.41^{2,3}$

[1] Exceeds limits for bars.

[2] Exceeds limits for structural.

[3] Exceeds limits for ductile iron pipe.

Table 24

Technical Limits of Obsolete Scrap Use in Selected Iron and Steel Construction Products

(Percent)

	Municipal			Nonmunicipal	
	Source-Separated Ferrous Cans	Incinerator Residue	Front-End Separated	No. 2 Bundle	Burned Slab
Bars	50 (100)[1]	90	100	100	100
Structural	25 (100)[1]	45	60 (85)[1]	90	70
Ductile Iron Pipe	25 (100)[1]	45	60 (90)[1]	90	85

[1] Numbers in parentheses show technical limits if tin content removed from the scrap.

scrap sources can be charged from 45-100 percent. However, de-tinning would increase the technical limits to 100 percent for all products with source-separated scrap, and a minimum of 85 percent with front-end-separated scrap.

Since there are apt to be significant variations in scrap quality and content, it would be wise to impose a safety factor on the limits set in Table 24. Using a safety factor of 2, Table 25 shows the potential percentage and tonnage of scrap use for each product type, using as the worst case, a scrap input consisting entirely of un-de-tinned source-separated ferrous cans. The total of 2.24 million tons accounts for 40 percent of the ferrous containers in the municipal solid waste stream.

Beyond the tolerance of steel products for the contaminant levels commonly found in municipal scrap, there are other technical and economic issues that affect the steel industry's willingness to use municipal ferrous scrap in their products. The issues are:

- Furnace problems. Elements responsible for furnace problems are lead, aluminum, and copper. Lead and aluminum are potentially damaging to refractory materials, and may necessitate more frequent furnace re-lining than normal. Copper is potentially harmful in the electric furnace, since it causes a cake to form on the electrode, which in turn may break the electrode. This necessitates shutting down the furnace and retrieving and replacing the electrode.

- Pollution problems. Lead is responsible for lead oxide emissions, which may be a significant environmental and occupational health hazard.

- Continuous casting. Where the continuous casting process is employed, alumina from aluminum contaminants tends to plug the nozzles used in the process, necessitating more frequent cleaning and replacement.

- Metal losses. The high surface area-to-weight ratio of can scrap may cause high levels of oxidation when heat is applied to the scrap, resulting in losses of iron in the form of iron oxide.

- Alloys. Alloying elements can be added to the melt to counter impurities. However, they are expensive, and some are currently in short supply.

- Scrap handling. Low-density can scrap is more costly to handle, on a per-ton basis, than other, more dense forms of scrap.

Table 25

Potential Use of Un-detinned Ferrous Cans in Selected Products

(Safety Factor = 2)

	Shipments MM Tons	Percent Scrap	Scrap MM Tons
Bars	3.42	25	0.86
Structural	8.54	12	1.02
Ductile Iron Pipe	3.00	12	0.36
Total	14.96	15	2.24

- Longer melt time. High contaminant levels and the possible need for alloys may require a longer melt time per batch of steel, resulting in reduced furnace capacity.

- Contamination of other products. Low-grade scrap, suitable for a construction-grade steel, may be totally unacceptable for other types, such as automobile sheet. Integrated mills typically produce a wide range of products, and they must exert careful control over the use of their various scrap stockpiles. Use of municipal scrap would require segregation from other materials and careful control of its use. However, integrated mills often use home scrap interchangeably for a variety of steel types. If a low-grade scrap were used to make a particular product, it might be necessary to restrict the resultant home scrap to melts of that product.

POTENTIAL FEDERAL IMPACTS

The Federal Government purchases, either directly or indirectly, significant quantities - 2.73 million tons, or 18 percent of the total national shipment - of the three iron and steel construction products discussed above. (See Table 26.) Thirty percent of these purchases are used by direct programs, while 70 percent are used in indirect programs.

Additional tonnage of post consumer waste ferrous scrap could be used in the iron and steel products purchased by the Government. (See Table 27. These tonnages are based on the substitution potential shown in Table 25, assuming the scrap is un-de-tinned ferrous cans.) The total Federal consumption would be 0.47 million tons, or about 8 percent of the 5.62 million tons of ferrous cans in the municipal solid waste stream. (See Table 28 for a summary of the potential Federal impact of each of the four major waste areas examined.)

Table 26

Federal Procurement of Iron and Steel Construction Products

(Million Tons/Year)

	Total Direct	Total Indirect	Total Federal	Major Agency
Structural Steel	0.36	0.96	1.32	0.55[1]
Reinforcing Bars	0.41	0.68	1.09	0.39[1]
Cast Iron Pipe	0.06	0.26	0.32	0.13[2]
Total Iron & Steel	0.83	1.90	2.73	1.07

Table 27

Potential Use of PCW Ferrous Scrap In Federal Construction

(Million Tons/Year)

	Total Direct	Total Indirect	Total Federal	Major Agency
Structural Steel	0.04	0.12	0.16	0.07[1]
Reinforcing Bars	0.10	0.17	0.27	0.10[1]
Cast Iron Pipe	0.01	0.03	0.04	0.02[2]
Total Iron & Steel	0.15	0.32	0.47	0.19

[1] Department of Transportation

[2] Department of Housing and Urban Development

Table 28

Summary of Potential Federal Impacts And Factors Related to Increased PCW Usage In Construction Products

Waste Material	Potential Additional PCW Use in Federal Construction		Factors Related to Increased PCW Usage in Construction Products	
	MM Tons/Year	% of MSW	Favorable	Constraints
Ferrous	0.47	8[1]	. Waste supply less of a problem than for glass or plastics	. Some industry resistance expected (less problem for reinforcing steel or iron pipe than structural steel)
Glass	1.43	12		. Supply of waste glass - dependent upon resource recovery plants . New products - market acceptance not demonstrated
Plastics	0.03	1		. Supply of waste plastics - polymer contamination is a major problem
Paper	0.46	1.0[2]	. GSA has modified Federal specifications to require PCW in construction paper	. PCW use in hardboard constrained by manufacturing process and plant location

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[1] Percentage of ferrous containers in MSW.

[2] Percentage of paper remaining in MSW after recycling at current rates.

***

In summary, our examination of the potential of increased use of ferrous scrap in iron and steel construction products showed:

1. Iron and steel construction products are potentially significant markets for municipal ferrous scrap. In particular, bars, structural shapes, and iron pipe could safely consume 2.24 million tons of un-de-tinned, source-separated ferrous cans, or 40 percent of ferrous containers in municipal solid waste. Of this amount, the total Federal share would represent 0.47 million tons.

2. The contaminants in municipal ferrous scrap, while acceptable for product requirements, can cause technical and economic problems for the producing mill - and these problems could result in higher product costs.

3. Specifications requiring municipal ferrous scrap in construction products could lead to dislocations within the industry. Integrated mills, especially the basic-oxygen furnace, would resist using municipal scrap, but the dislocations would be less severe for bars and iron pipe than for structural shapes.

B. GLASS

USES OF GLASS IN CONSTRUCTION

In 1972, 16 million tons of glass products were produced, with 2.7 million tons consumed by the construction industry. (See Table 29.) The three major manufacturing segments are containers, accounting for approximately 11.6 million tons, or 73 percent, of the total glass shipments; flat glass, accounting for 2.4 million tons; and pressed and blown glass, consuming 2.0 million tons.

The two significant glass products used in construction are window glass, comprising 83 percent of all flat glass shipments (about 2.0 million tons) and glass insulation, comprising 35 percent of all pressed and blown glass (about 0.7 million tons). Together, these products total 2.7 million tons, or 17 percent of total glass shipments.

The only cullet (glass scrap) currently used in window glass and glass insulation is home cullet. However, small quantities of

Table 29

Glass Shipments and Construction Markets - 1972*

Glass Type	Shipments (MM Tons)	Percent of Total Shipments
Containers	11.6	73
Flat	2.4	15
Windows for Buildings	2.0	13
Pressed and Blown	2.0	12
Glass Insulation	0.7	4
Total Production	16.0	100
Total Construction Market	2.7	17

*Source: Resource Planning Associates, Inc., A Resource Recovery Report on Glass, 1973.

Midwest Research Institute, The Commercial Potential of Glass Wool Insulation.

container cullet have been used by one small manufacturer of insulation. But container cullet has a markedly different, and inferior, chemical composition from the flat and pressed/blown glass, and therefore can usually not be used in the manufacture of existing types of glass products. Thus, the greatest potential for using waste glass in construction is in new products.

SUPPLY OF WASTE GLASS

Waste containers represent the only type of cullet available in reasonable quantities and in a form suitable for recovery. (Flat glass, for instance, is usually not recoverable after use; when a building is demolished, the window glass is typically pulverized and combined with plaster, concrete dust, and dirt, and then discarded.) Assuming all containers shipped in a given year were disposed of in the same year, a maximum of 11.6 million tons entered the waste stream in 1972.

Most of the cullet recycled today comes from source separation or recycling programs in which citizens voluntarily separate their glass, by color, for shipment to one of the glass container manufacturers. Currently, the manufacturers will accept a certain amount of color mixing (up to 30 percent for amber or green glass), but specifications are quite restrictive regarding contamination with foreign materials such as ceramics and stone. Prices for source-separated cullet range from $20 to $30 per ton at the container manufacturing plant. As will be shown later in the discussion, only a few of the potential construction uses for waste glass can competitively support cullet prices at this level.

Resource recovery plants are expected to be a major future source of cullet. Although the technology is still in its infancy, separation through front-end or back-end recovery systems is feasible and has been demonstrated at the pilot stage. Examples are the Sortex optical sorting system in operation at the Franklin, Ohio, demonstration resource recovery plant, and the Garrett Research and Development Company tests of a froth flotation system to separate the glass fraction.

Since these processing facilities must deal with mixed refuse, they typically yield a cullet product that is lower in quality than source-separated cullet. The color sorting is expensive and is not 100-percent effective; there is always some contamination with the organics, ceramics, and metallics present in the mixed refuse. As a result, this cullet is a lower quality product generally unsuitable for reuse in container manufacture. However, many of the new construction products were developed to use this form of cullet. As a means of judging the economic viability of manufacturing new construction products from cullet, a graph - Figure 5 - has been developed to demonstrate the relationship between the quality, or degree of purity of the separated glass, and the associated separation costs.

A major issue related to cullet supply for construction products is the rate at which resource recovery plants will be coming on line, since most source-separated cullet is likely to be used in container manufacture. A recent study[8] projected that by 1980, the equivalent of 36 1,000-ton-per-day energy recovery plants (which may or may not have glass recovery subsystems) will be in operation, based on projects that exist or are presently in the planning stage. The same study estimated that, if energy recovery systems were developed in all areas of the country where economically feasible, 170 1,000-ton-per-day plants would be on line by 1980.

Assuming that in 1980, glass represents approximately 10 percent, by weight, of municipal solid waste, as it did in 1974, the maximum glass flow through these resource recovery systems would be 900,000 tons to 4.25 million tons per year. However, glass subsystems will probably not be installed in all of these resource recovery systems, and for those that do install such a subsystem, less than 100 percent of the available glass will actually be recovered. Therefore, assuming 50 percent of the systems have glass subsystems, and that 75 percent of the glass throughput is technically recoverable, glass availability from resource recovery systems in 1980 would actually be about 300,000 to 1.6 million tons per year.

Other issues related to the supply of waste glass for construction products are:

- Glass recovery technology. Improvements in glass recovery technology could result in high-quality cullet suitable for use in containers, thereby diverting cullet from construction uses.
- Source-reduction legislation. National interest in the use of returnable beverage containers is increasing. A major shift away from throwaways would reduce the tonnage of glass containers in the waste stream.

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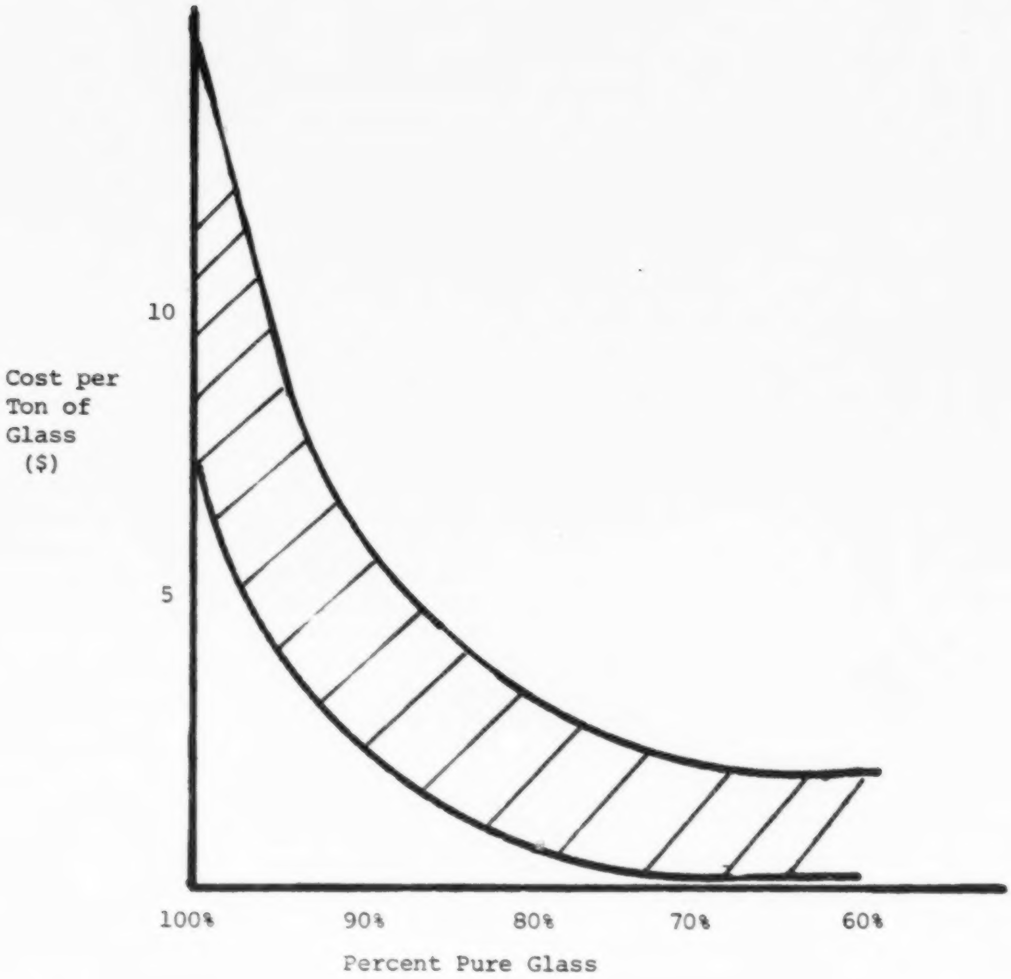
[8] U.S. Environmental Protection Agency, Energy Conservation through Improved Solid Waste Management, 1974.

Figure 5

COST OF MECHANICAL SEPARATION *



*Source: Resource Planning Associates, Inc.

POTENTIAL FOR WASTE GLASS USE IN NEW CONSTRUCTION PRODUCTS

During the last decade, over a dozen separate construction products using waste glass have been developed and tested; some are being manufactured commercially from source-separated glass. Much of this development work has been sponsored and funded by the glass container industry, either independently or through their association, the Glass Container Manufacturers Institute. The actual work has been carried out by universities, local governments, and private industry. The Federal Government has taken a major, direct role, primarily through the U.S. Bureau of Mines.

In this effort, we focused our evaluation on 13 products that have been proven technologically; that is, each can be produced on a large scale and can satisfactorily perform the functions for which it was designed. (See Table 30.)* These 13 are:

> _Terrazzo_. Terrazzo floors are made with a colorful aggregate, set in cement, and polished until smooth. Glass chips can be used instead of the traditional marble chips.
>
> _Thixite®_. A strong and attractive tile or panel can be made with rubble, finely crushed glass, and clay, which is vibratory cast and fired. Decorative effects can be achieved with different aggregates (including glass chips) and surface treatments.
>
> _Pozzolan_. Waste glass is finely ground and used as a concrete additive to counteract reactions between cement and certain silicone aggregates.
>
> _Foamed glass panels_. Waste glass is heated in the presence of an organic material, which volatilizes and causes the cooled glass mass to be porous. Many nonstructural materials can be made in this manner by using varying weights and surface treatments.
>
> _Ceramic bricks_. Glass can be used as a substitute for a portion of the clay in common ceramic brick. Its use results in significant energy savings.

---

*A detailed description of each product is provided in Appendix C, including a technical description of the function, the status of development, unique advantages, constraints, necessary plant investment, quality of glass required, economics, market segment and size, person or firm to contact for information on the product, and technical reports on the product.

Table 30

Waste Glass Construction Product Opportunities*

TABLE I

Product	Status[1]	Waste Glass Market Size - 1973[2] (Million Tons per Year)
Terrazzo Floors	Demonstrated	.8
Thixite^{R}	Demonstrated	1.4
Pozzolan	Experimental	.8
Foamed Panels	Demonstrated	1.5
Ceramic Bricks	Demonstrated	7.1
Glass-Excreta Tiles	Demonstrated	.3
Foamed Light-Weight Aggregate	Experimental	5.7
Glass Wool Insulation	Commercial	.5
Glass Polymer Concrete	Demonstrated	2.7
Glasphalt	Demonstrated	150.0
Slurry Seal	Demonstrated	1.4
Glass-Portland Cement Concrete	Demonstrated	16.0
Tekbloks®	Demonstrated	40.0

---

[1] Experimental: Technical performance demonstrated in laboratory
Demonstrated: At least one pilot demonstration in an actual construction application
Commercial: Product being marketed commercially

[2] Compares with maximum of 1.6 million tons/year available from resource recovery plants by 1980.

*Source: Resource Planning Associates estimates, published reports on products (see Appendix C), and construction material industry production statistics.

Glass excreta tile. Ground glass and certain organic materials, such as cow dung, are fired under pressure to produce a strong, light-weight tile.

Foamed light-weight aggregate. Ground glass can be heated so that it foams into strong porous nuggets that can be used for concrete aggregate. Less energy is consumed in this process than in traditional bloated shale aggregates.

Glass wool. The familiar glass fiber product used for insulation can be made with large percentages of waste glass, resulting in energy savings.

Glass polymer concrete. Small amounts of plastic resins can be mixed with inert aggregates, such as glass, to form a strong, corrosion-resistant concrete, useful for sewer pipes and other products.

Glasphalt. Glass can be substituted for a portion of the stone aggregate in asphalt pavements.

Slurry seal. Slurry seal is a specially prepared and cured protective surface for roads. Crushed glass can be utilized for all or a portion of the aggregate.

Glass-Portland-cement concrete. Glass can be used as a replacement for concrete aggregate, especially for its decorative effect. However, some loss of strength has been observed.

Tekbloks®. A patented process forms bricks or blocks using glass or any inert aggregate in combination with cement and chemicals. The mixture is cured under pressure.

An economic comparison of these products is presented in Figure 6. For each product two types of figures are presented: (1) the estimated *value* at which the cullet product is competitive with "virgin" products, and (2) the estimated *cost* of separating the glass at the required quality/purity in a resource-recovery system.* The spread between these two numbers is an indication of the economic viability of the product.

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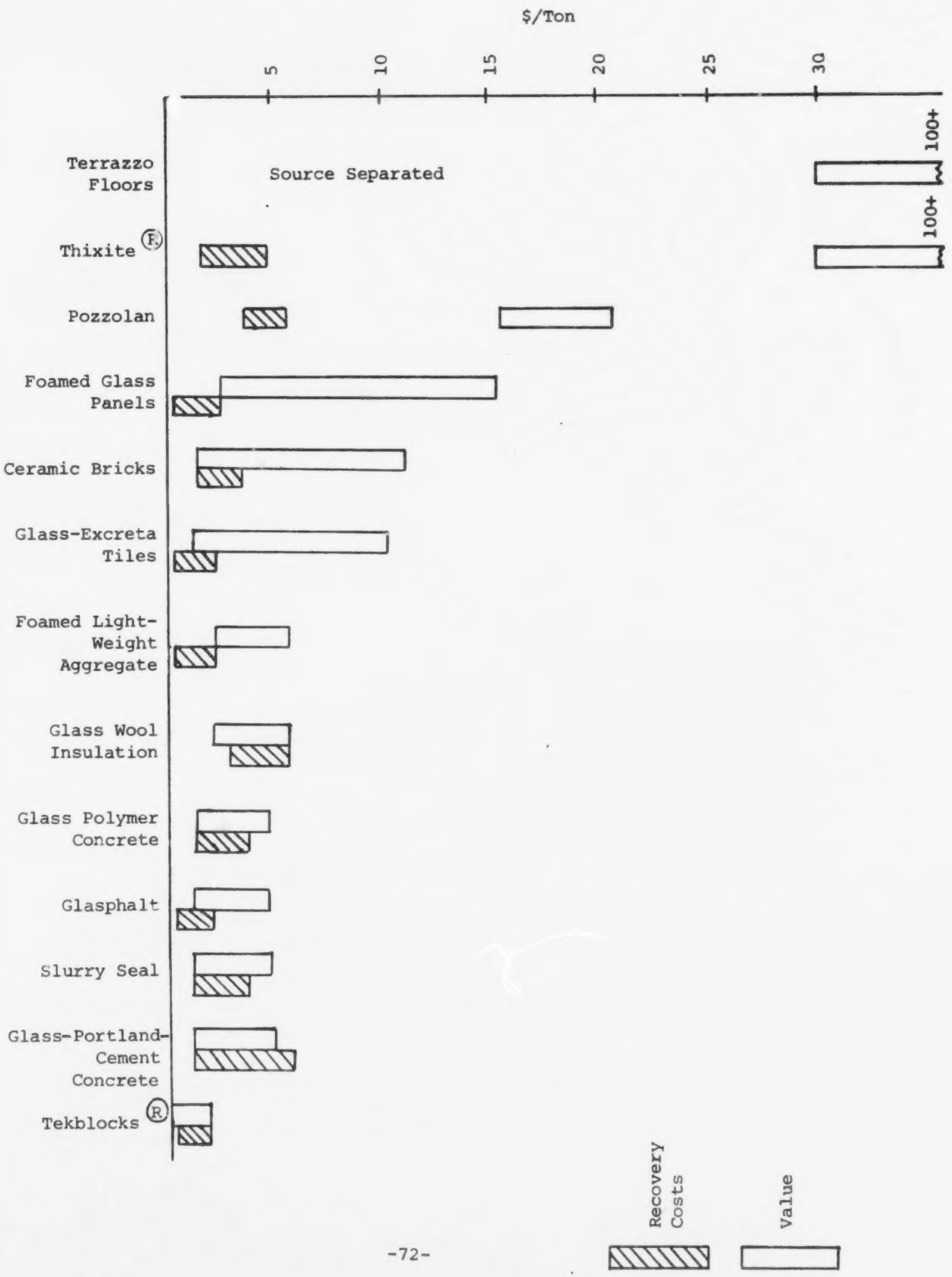
*Estimates are approximate, based on industry data from laboratory and pilot-scale projects.

Figure 6

ECONOMIC COMPARISON OF WASTE GLASS CONSTRUCTION PRODUCTS



Although potential market size and economic comparisons are useful starting points, a number of other factors impact on whether a particular product will succeed or fail in the marketplace. Consequently, in the remainder of this subsection, we first examine the major factors that influence the success or failure of new products, and then apply these factors in an analysis of three specific opportunities, ceramic bricks, glass-excreta tiles, and foamed panels.

Influencing Factors

There are two broad categories of factors that must be considered: (1) those affecting the manufacturers of products made from waste glass, and (2) those affecting the suppliers of the waste glass (i.e., resource recovery system owners).

Product manufacturer. The product manufacturer must consider five factors:

1. Product uniqueness. A new product that meets a market segment's needs better than an existing product will likely have more success than a new product that offers no advantages over an existing product. New product developers will find that selling is a major expense, and that preselling may be necessary before either architects or builders accept the product. Clearly, distinct product advantages will reduce the need for a preselling effort.

   It is thus important for the manufacturer to understand the needs of the market and to address those needs via the product. These needs may be in the form of product performance or ease of installation, or they may relate to manufacturing costs of construction products or scarcity of resources. An example of the latter is the inherent potential for energy conservation with the use of cullet in the manufacturing process. Energy is becoming a scarce resource, and substantial quantities are required in the manufacture of bricks. The use of cullet in brick manufacture speeds the production process and conserves energy.

2. Industry structure. The developer of a new product must understand the structure of the industry that manufactures and sells competing products. Of particular importance are concentration (i.e., the number and size of firms presently in the business), channels of distribution (i.e., how present

manufacturers sell their products to the end consumers), and barriers to entry (i.e., building codes and other regulations).

Firms presently in the business may indeed be viewed as competitors, but the possibility of licensing new product development to these firms should also be considered. This may, in fact, be the only way to develop market share for a new product. For instance, the existing glass wool insulation industry is concentrated in four large firms, and is fully capable of overwhelming fledgling ventures making glass wool from container cullet.

3. Product marketing. Product marketing relates to the previous issues of product uniqueness and industry structure, and is essential for the success of a new product. To be successful, the producer must convince the consumer to buy the product at a price that will sustain the firm. There are a number of ways to "sell" the consumer, including advertising, discounting, and promotions.

   The distributor may play an important role in the selling effort, and the producer may need the distributor to "push" the product to the consumer. It may be difficult for a new producer to enter the existing distribution channels for competing construction products. This, then, is another possible argument for entering into joint ventures or licensing arrangements with existing manufacturers; such ventures would take advantage of established marketing and distribution networks.

4. Reliability of waste glass supply. Since cullet will be a key raw material ingredient of the new product, the producer must be assured of a timely flow of materials that meet established specifications. The importance of these factors depends on the particular product. For instance, bricks made with glass as a flux can also be made entirely from clay, and the brick manufacturer could continue to produce in the absence of glass supply. The production of glass-excreta tiles, on the other hand, would cease without a supply of glass.

   Supply factors will vary greatly throughout the country. Some waste-producing centers, although their entire product would be available for construction products, are located far from glass container plants. On a nationwide basis, 300,000-1.6 million tons of available waste glass per year would not seem likely to have much impact on some of the larger markets listed in Table 27. But on a regional basis, these glass supplies might become available in concentrated pockets, and could flood more than one of the markets, even assuming good market penetration.

5. Investment and risks. The relationship between investment and risks is basic to any business venture. If the required investment for plant or market development of a product were high and the associated risks were high, the prospects of attracting entrepeneurs would be poor. Such is the case with glass wool and, to a lesser extent, with foamed glass panels. A glass wool plant will require an investment of about $2 million, more than that required for any other product, and there are risks associated with obtaining a consistent quality and quantity of waste glass. Furthermore, it is not known exactly what contaminants can be tolerated to produce a commercial-grade glass wool. Some of the risks can be mitigated with an experimentation program, but investments of this magnitude are best taken by large firms already in the business.

   At the other end of the scale are the products - such as bricks, slurry seal, glasphalt, and Tekbloks® - in which glass is substituted, when available, as an ingredient. No large investment is necessary because the existing plant will continue to operate with or without the glass. Moreover, no investment or risks are involved in marketing because the basic character of the product does not change. And risks stemming from the quality of glass input are low because the level of contaminants is not critical in such products.

Resource recovery system owners. There are four factors important to the owners/operators of resource recovery systems:

1. Impact of demand for construction-product cullet on waste supply. Clearly, since glass is a relatively small portion of the solid waste stream, investment decisions on total resource recovery systems are not expected to be heavily influenced by the glass

markets. However, since some form of subsystem will be necessary to process, recover, and store the cullet, the system owner must be assured that the market demand justifies the investments required.

2. Reliability of demand. Of equal importance to the size of the demand for cullet is the reliability of the demand. This is closely related to the viability of the construction products made from the waste and to the "staying power" of the product manufacturers. The resource recovery system owner needs to be assured that his investment in a cullet subsystem will be fully paid off over time, and will yield a reasonable profit.

3. User delivery and quality requirements. This factor is closely related to the first two. If a product manufacturer required high-quality cullet, or required that cullet be delivered on a demanding time schedule, then the resource recovery system owner may be forced to guarantee both the quality and the quantity of his supply of cullet.

4. Availability of alternate markets for waste. To minimize the aforementioned risks, the system owner may wish to develop several alternative markets for the waste glass from his system. These could either be two or more manufacturers of the same product (e.g., bricks), or manufacturers of different products with the same cullet requirements. With two or more buyers, the system owner could assure price competition for his cullet. Should a product fail, he could continue to sell at least some of the waste material.

It is evident that many of the uncertainties facing the product manufacturer and the waste supplier stem from their mode of interaction. It is therefore anticipated that resource recovery systems and the construction products may develop as a joint venture between the system owners and product manufacturers. In this way, both parties would share common risks, and a major source of uncertainty for both would be eliminated.

Analysis of Selected New Construction Products

Glass-excreta tiles, foamed panels, and ceramic bricks were chosen for analysis because each represents a sizable market for waste glass. At 10-percent market penetration, the brick demand would approach 50 percent of the waste glass availability in 1980; similarly, the other two products, taken together, would account for 10-20 percent of the total avilable cullet in these years. In addition, each appears economically attractive - i.e., the product could support a cullet price substantially higher than the cost of recovering the cullet in a resource recovery system. (See Figure 6.)

Foamed panels and glass-excreta tiles. These two products have been grouped together because of their similarity and the possibility they would be produced in a common plant.

Issues facing manufacturers.

Product uniqueness. Foamed panels and glass-excreta tiles are light-weight, fireproof, and attractive. Additionally, the foamed panels could potentially be sold at a price considerably less than competing products. For example, it is estimated[9] that a selling price of 6 cents per board-foot would yield the producer an after-tax return on investment of 23.3 percent; competing products sell for 20-22 cents per board-foot.

Industry structure. Foamed panels and glass-excreta tiles could potentially compete with materials made by a variety of industrial firms. These firms typically make a wide range of construction products and sell them through a highly developed distribution system. The industries for each type of product consist of several large firms (4-10) with a dominant share of the market (60-90 percent), plus a number of smaller firms that sometimes serve only regional markets. There is a growing trend for the larger manufacturers to take an increasing share of the total market.

Product marketing. Although the two products have good technical-performance characteristics and are potentially available at competitive prices, marketing would be a major problem. It would be logical for existing distribution channels to carry the new products. However, actually to sell the product, the manufacturer must either create demand at the consumer level through advertising or other means, or he must get assistance from the distributor/wholesaler who can "push" the products in a number of ways. Advertising would probably not be an economical alternative at this stage of the product life cycle, so the manufacturer would have to depend heavily on the selling ability of the distribution network.

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[9] Midwest Research Institute, Commercial Potential for Foamed Glass Construction Materials Made with Waste Glass and Animal Excreta.

One approach to minimizing the marketing risks would be for the manufacturer of new products to establish joint venture or licensing arrangements with one or more of the large building material suppliers. This could have substantial benefit since these suppliers have ready access to the entire distribution network for building products and their influence with distributors could help introduce new products. Furthermore, a joint venture could be attractive to large suppliers interested in diversifying present product lines.

Another approach to reducing risk - a joint venture between manufacturer and resource recovery system owner - would be possible. For example, informal discussions are being held between Environ Control Products and officials of San Diego County, who are involved with developing a pyrolysis resource recovery system for the county. These officials have indicated that the county might fund Environ Control Products to build a plant to make products from San Diego's glass wastes.

Reliability of waste glass supply. Foamed panels and glass-excreta tiles have a 95-percent cullet content; thus, glass supply is of great importance to the success of these products. The producer, however, will probably have one source of supply. That is, at the outset, there will be only one resource recovery system within economical shipping distance of the manufacturing plant.

Investment and risks. The investment required for an economical plant size is $500,000. A 10-percent market penetration in a region of 15 million people (representing maximum economical shipping distance) would require a $1-million investment.

Issues facing resource recovery system owners.

Impact of demand for construction-product cullet on waste supply. Plants would utilize from 25 to 50 tons per day, depending on plant size. This represents 12-25 percent of the glass output of a 2,000-ton-per-day resource recovery plant, thereby necessitating that other markets for the waste glass be found.

Reliability of demand. The major problem here relates to the viability of the product in the marketplace. If it sold at a price that provided sufficient economic return to the manufacturer, demand would be guaranteed; if the business failed, demand would be nonexistent.

User delivery and quality requirements. The cullet quality requirements are relatively low and flexible. The glass used in making these products can be relatively contaminated with dirt, metals, and the like. But timely delivery will be of major importance to the buyer. In the event of system shutdown, the buyer will either have a sufficient supply in inventory, or he will demand delivery as promised. The system owner can assure compliance by maintaining an emergency inventory of glass at the resource recovery plant.

Availability of alternate markets for waste. As mentioned above, the system owner must attempt to locate markets for the remaining 75 percent of the waste glass.

Ceramic bricks. In contrast to foamed glass panels and glass-excreta tiles, the ceramic brick opportunity is an attractive market for cullet that entails little risk for either the brick manufacturer or the resource recovery system owner.

Issues facing manufacturers.

Product uniqueness. This product uses glass as a flux in the manufacture of clay bricks. Besides saving clay, a scarce resource, the use of glass conserves energy. Brickmaking is an energy-intensive industry, and the brickmaker will welcome anything that reduces his dependence on energy. Additionally, the shorter kiln time increases plant capacity and can boost production, if desired.

Industry structure. The brickmaking industry is fragmented. Typically, local production serves only local markets. Most manufacturers have a clay pit as part of their operation. Average annual sales amount to approximately $1-2 million per brick producer.

Product marketing. Brick producers will experience no difficulty in marketing these bricks since they are similar in appearance and performance to bricks produced without glass.

Reliability of waste glass supply. Since the brickmaker can produce bricks with or without the glass, and since he has a captive supply of clay, it is evident that cullet supply variations would not be a major problem. If the resource recovery plant were to be delayed in opening or shut down for maintenance or equipment replacement, it would not be damaging to the brickmaker.

Investment and risks. The capital investment required to accept and use glass at a typical brickyard is less than $50,000. The risks, as described above, are minimal.

Issues facing resource recovery system owners.

Impact of demand for construction-product cullet on waste supply. A typical brickyard might require 60 tons of cullet per day. Given the geographical dispersion of brickmaking facilities across the country, it is assumed that one resource recovery plant could economically serve at least two brick plants. This amounts to 120 tons of cullet per day, or over 50 percent of the total waste glass theoretically available from a 2,000-ton-per-day plant.

Reliability of demand. The reliability of demand is high in this instance. Once the brickmaker has signed a contract to purchase a given quantity of cullet, the resource recovery system owner need not be concerned, since there is little danger of the brickmaker going out of business.

User delivery and quality requirements. Some cullet cleaning is required, especially to remove metals. However, delivery requirements are more flexible since the brickmaker can, on relatively short notice, accept varying quantities of glass, ranging from zero to the full contract amount.

Availability of alternate markets for waste. The system owner will need to locate markets for the 50 percent of his cullet not sold to the brickmaker.

POTENTIAL FEDERAL IMPACTS

The Federal Government purchases large quantities of the construction materials that could be manufactured from waste glass - ceramic bricks, wall surfacing (e.g., foamed glass panels), and flooring (e.g., terrazzo) materials. (See Table 30. The purchases of wall surfacing and flooring are given in terms of square footage because of the great variety of materials that could be used in these products.) The major government purchaser of these materials is the Department of Health, Education, and Welfare, which accounts for about 40 percent of total Federal consumption. Direct procurement accounts for 30 percent of the purchases, while the remaining 70 percent is purchased indirectly.

Potentially, the Federal Government could consume 1.43 million tons of waste glass in its construction projects, or about 12 percent of the glass containers in the solid waste stream. (See Table 32.) This also represents nearly 90 percent of the 1.6 million tons of waste glass that might be available from resource recovery plants by 1980. The purchases of the Department of Health, Education, and Welfare alone could consume about 600,000 tons of glass annually, or 5 percent of the glass containers in the waste stream.

Table 31

Federal Procurement of Construction Materials That Could Contain Waste Glass

	Total Direct	Total Indirect	Total Federal	Major Agency
Ceramic Bricks (000 tons)	499	1,031	1,530	648[1]
Wall Surfacing (MM SF)	195	429	624	237[1]
Flooring (MM SF)	71	149	220	95[1]

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[1] Department of Health, Education, and Welfare

Table 32

Potential Use of Waste Glass In Federal Construction*

(Million Tons/Year)

	Total Direct	Total Indirect	Total Federal	Major Agency
Ceramic Bricks	0.17	0.36	0.53	0.23[1]
Wall Surfacing (Foamed Glass Panels)	0.08	0.17	0.25	0.09[1]
Flooring (Terrazzo)	0.21	0.44	0.65	0.28[1]
Total	0.46	0.97	1.43	0.60

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[1] Department of Health, Education and Welfare

*Source: Published product information

Resource Planning Associates estimates.

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In summary, our analysis of the possibility of increasing the use of waste glass in construction products showed that:

1. There are a number of attractive opportunities to use waste glass in new construction products.
    - a. Most of the products do not require the high-quality cullet used in containers and cannot compete economically for container-quality cullet.
    - b. Two of the products - thixite wall panels and terrazzo floors - require container-quality cullet and can support a cullet price of $30 + per ton.
    - c. All of the products are still in the experimental stage, or at most have had some commercial exposure. Market acceptance is a major unknown.
2. The supply of waste glass for most construction products is limited by the number of resource recovery plants.
    - a. Source-separated cullet will be diverted to container manufacture and possibly to the manufacture of thixite wall panels and terrazzo floors.
    - b. The lower-quality cullet from resource recovery plants is well suited to many construction uses.
3. For products dependent on resource recovery systems as a source of cullet supply, there are two major risks related to product success.
    - a. Product acceptance, which is not a problem for established products (e.g., clay bricks using glass as a flux), but may be a major problem for new products such as glass-excreta tiles.
    - b. Willingness and capacity of the resource recovery system operator to provide long-term cullet at the required quality and quantity.

C. PLASTICS

USES OF PLASTICS IN CONSTRUCTION

The two major categories of plastics (or plastic resins) are thermoplastics and thermosets. Thermosets, representing approximately 20 percent of all plastics, cannot be remelted after the first heating cycle; thus, recycling of thermosets is difficult. However, thermoplastics, which comprise about 80 percent of all plastics, can be remelted and reshaped.

In 1973, plastics production reached 13.2 million tons. (See Table 33.) Approximately 90 percent of all thermoplastics are the "Big Five" polymers: high-density polyethylene (HDPE), low-density polyethylene (LDPE), polypropylene (PP), polystyrene and acrylonitrile-butadiene-styrene (PS/ABS), and polyvinyl chloride (PVC). And nearly all plastics in the solid waste stream are members of the "Big Five."

The largest plastic resin consumer is the construction industry, consuming 2.9 million tons, or 22 percent, of total resin production. (See Table 34.) Moreover, the market for plastics in construction is growing at an annual rate of 18 percent, well above the average growth rate of 14 percent for all plastic resin markets. But despite the large size of the plastics market in construction, plastics account for less than 5 percent of all construction materials used.[10]

Within the building/construction industry, thermoplastics comprise 70 percent of construction plastics; thermosets make up the remaining 30 percent. (See Table 35.) Of the thermoplastics, PVC accounts for 58 percent (by weight); LDPE is 15 percent; PS/ABS is 13 percent; and HDPE, PP, and other make up the remaining 14 percent. Construction products represent the major end use for PVC resin - 46 percent of total PVC shipments. The dominance of PVC in construction is explained by its excellent strength, durability, and weather resistance. Resin use in the three major thermoplastic construction products - pipe, wire and cable, and flooring, which represent 80 percent of thermoplastics used in construction. (See Table 36.)

The market for construction plastics is growing rapidly, at the expense of the more traditional building materials such as steel, copper, and wood. For example, plastic pipe sales have quadrupled

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[10] Modern Plastics, October 1973, p. 83.

Table 33

Plastic Resin Shipments - 1973*

Polymer Type	Shipments (1000 Tons)
Thermoplastics	
High-density polyethylene (HDPE)	1,254
Low-density polyethylene (LDPE)	2,664
Polypropylene (PP)	978
Polystyrene and acrylonitrile-butadiene-styrene (PS/ABS)	2,407
Polyvinyl chloride (PVC)	2,171
Total "BIG 5" Thermoplastics	9,474
Other Thermoplastics	938
Total Thermoplastics	10,412
Thermosets	2,770
Total All Plastics	13,182

*Source: Modern Plastics, January 1974.

Table 34

Plastic Resin Markets - 1973*

Market	Shipments (1000 tons)	Percent of Total Resin Production	Growth Rate (Percent) (1972-73)
Building/Construction**	2,926.4	22	18
Packaging	2,644	20	12
Transportation	703.5	5	N/A
Housewares	618	5	13
Furniture	496.5	4	9
Appliances	425.3	3	22
Toys	400	3	22
Electrical/Electronics**	271.8	2	11
Other	4,696.5	36	N/A
Total - All Markets	13,182	100	14

*Source: Modern Plastics, January 1964.

**Wire and cable included in Building/Construction; not Electrical/Electronics.

Table 35

Plastic Resins Used in Building/Construction - 1973*

(1000 tons)

Polymer / Product	Thermoplastics						Total Thermo-plastics	Thermosets	Total
	HDPE	LDPE	PP	PS/ABS	PVC	OTHER			
Pipe/Fittings/Conduit	152	22	9	207	569		959	56.6	1,015.6
Wire and Cable		226	47		194	4.2	471.2		471.2
Resin-Bonded Woods								468.2	468.2
Flooring					211		211	19.5	230.5
Insulation				29			29	177	206.0
Panels/Siding				5	39	5.8	49.8	54.6	104.4
Vapor Barriers		70			29		99		99.0
Profile Extrusions	3.4				84		87.4		87.4
Light Fixtures				22	5	28.5	55.5	1.5	57.0
Wall Covering/ Wood Surfacing				2	54		56		56.0
Decorative Laminates								50.5	50.5
Glazing/Skylights						28.9	28.9	12.3	41.2
Plumbing/Bathroom Fixtures				3		5.4	8.4	31	39.4
Total Building/ Construction	155.4	318	56	268	1,185	72.8	2,055.2	871.2	2,926.4

*Source: Modern Plastics, January, 1974.

Table 36

Major Thermoplastic Construction Products - Resin Use in 1973 (1000 Tons)

Polymer / Product	HDPE	LDPE	PP	PS/ABS	PVC	TOTAL
Pipe/Fittings/Conduit	152	22	9	207	569	959
Wire and Cable		226	47		194	467
Flooring					211	211
Total	152	248	56	207	974	1,637

since 1968 and are expected to double their present level of about 1 million tons per year by 1978.[11] In addition, a new generation of plastic foam materials is similarly expected to replace lumber on a large scale. Indeed, at least one source[12] predicts plastics will compose 25 percent of construction materials by the turn of the century - a significant rise from the present 5-percent level.

There are many reasons for the encroachment of plastics on the markets for traditional construction materials, including the favorable performance characteristics of plastics and the severe shortages and price increases for the traditional materials. Moreover, plastics are lightweight and therefore easy to fabricate, transport, and install; they have a high strength-to-weight ratio, thereby making them suitable for structural applications; they are extremely durable and resistant to environmental deterioration (certain grades of plastic pipe are guaranteed for 50 years in subsurface installations); and their costs are competitive with other materials. Shortages of other materials such as steel, lumber, and copper have driven prices up and created market disruptions, thereby forcing buyers to seek alternatives. (However, it must be noted that the world petroleum situation has resulted in shortages and price increases in the plastics industry. Although it is too early to predict the long-term effects of this development, it may slow the growth of plastics for the short term.)

Building codes have been a barrier to use of plastic construction products, however. Local building officials have hesitated removing all code-related barriers to plastics use because of pressure from traditional material suppliers and uncertainty regarding the performance claims of plastic products. For instance, a 1973 survey[13] found that ABS pipe was approved for drain, waste, and vent applications in only 75 percent of all new residential construction areas. Thus, significant industry effort must be expended to develop credibility in plastic construction products.

Besides "virgin" plastics, there are secondary - or scrap - plastics. The secondary plastics used in construction products consist almost entirely of scrap generated in the manufacturer's own operations since producers hesitate to use scrap from outside sources because they cannot be certain of the chemical composition of outside scrap. In some cases, product specifications preclude the use of outside scrap due to risk of contamination.

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[11] Chemical Week, October 17, 1973, p. 53.

[12] Modern Plastics, October 1973, p. 83.

[13] Modern Plastics, May 1973, p. 71.

Contamination of the polymer resin is of particular concern in plastics manufacturing. Use of contaminated resin may degrade a product's physical properties, such as strength, color, heat resistance, and durability. Different polymers are generally incompatible when mixed together, and the structural strength of the resulting mixture is often less than that of either component. Even two different batches of the same polymer may be incompatible because of coloring, previous exposure to heat, or additives.

The two processes used to fabricate plastic construction products are extrusion and molding, accounting for approximately 70 and 30 percent of production, respectively. Although home scrap generation and re-use rates vary from one operation to the next, on the average, the extrusion process generates 15-percent scrap, while molding generates 10-percent scrap. About one-half of this scrap is reused as home scrap; most of the remainder is discarded.

SUPPLY OF SCRAP PLASTICS

Plastics are important components of the solid waste stream from an energy recovery point of view. Although plastics are only 3 percent by weight of municipal solid waste, they have a heating value of 16,000 Btu's per pound, and represent 10 percent of the energy content of the waste stream. Assuming an energy value of 18 cents per 1,000 Btu's (equivalent to oil at $11 per barrel), plastics would have a value of about 2.9 cents per pound, or $58 per ton. The value of plastics as a source of energy may limit the availability of plastics for recycling, particularly in view of the technological problems associated with polymer separation.

There are three major sources of plastic scrap for recycling: (1) reprocessed scrap; (2) discarded industrial scrap; and (3) municipal plastic scrap. (Table 37 lists the quantities of the five major thermoplastic resins in these three waste categories.) Each is discussed in turn below.

Reprocessed Scrap

Plastics recycling is currently limited to industrial scrap. Most is recycled as home scrap, but a portion is processed by the reprocessing industry and sold to industrial users as secondary resin. It is estimated that approximately 440,000 tons of scrap was recycled in

Table 37

Plastic Scrap Sources - 1973*
(1000 Tons)

	Prompt (Reprocessed) Scrap (1970 Data)	Discarded Plastic Scrap		Total
		Industrial	Municipal	
HDPE	33	31	868	932
LDPE	87	138	1,186	1,411
PP	30	42	210	282
PS	125	83	618	826
PVC	165	171	518	854
Total	440	465	3,400	4,305

*Source: Arthur D. Little, Inc., Incentives for Recycling and Reuse of Plastics, 1972.

Modern Plastics, January, February 1974.

Resource Planning Associates estimates.

1973 by the reprocessing industry,[14] representing less than 5 percent of the 1973 shipments of the five major thermoplastic resins. This small percentage of recycled prompt scrap reflects the reluctance of plastics manufacturers to use outside scrap.

Although no quantitative estimates are available, it is likely that the volume of reprocessed scrap plastic has decreased, or at best remained constant during the past year, as a result of petroleum shortages. The energy crisis has driven the price of plastic resin to new highs, and many of the fabricators and resin producers have installed machinery in their own plants to allow them to reuse as much scrap as possible. As a result, the amount of scrap flowing to the reprocessor has been reduced. Table 38 shows the change in quoted prices for virgin resin between February 4 and June 10, 1974. During this period, prices increased from 14 to 80 percent.

The price for secondary resin (after reprocessing) is comparable to the price of "off-grade" resin, a form of virgin plastic that is slightly lower in quality than top-grade material.[15] Good virgin resin sells for approximately 10 percent more than the price of off-grade resin. Thus, using the June 10 virgin resin figures in Table 38, the corresponding secondary resin prices would be 16 cents per pound for HDPE, 15 cents for LDPE, 17 cents for PP, 23 cents for PS, and 26 cents for PVC.

Specifications for secondary resin vary, depending on the fabrication process (e.g., extrusion, molding) and the products for which it is used. Most applications require an uncontaminated material, free from other polymer types and particulate matter.

Discarded Industrial Scrap

Discarded industrial scrap, or "nuisance plastic", is badly contaminated material (e.g., plastic-coated fabric) for which recovery is as yet uneconomical. In past years, "nuisance plastic" has been neither reused nor reprocessed. This scrap amounted to about 465,000 tons in 1973, or about 5 percent of total resin production. There are indications[16], however, that the amount of "nuisance plastic" has

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[14] Arthur D. Little, Inc., Incentives for Recycling and Reuse of Plastics, 1972.

[15] Ibid.

[16] Modern Plastics, February 1974.

Table 38

Virgin Resin Prices*[1]

(Cents per Pound)

	February 4, 1974	June 10, 1974	Percent Increase
HDPE	16	19	19
LDPE	13.5	18	33
PP	18	20.5	14
PS	15	27	80
PVC	24	30	25

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[1] Prices are the average of high and low quoted prices for the day indicated--large lots, F.O.B., New York.

*Source: Chemical Marketing Reporter, February 4 and June 10, 1974.

decreased by 25 percent from the previous year because of resin price increases and increased interest in material reuse.

Municipal Plastic Scrap

Plastics amounted to about 3.4 million tons, or 3 percent by weight, of the municipal solid waste stream in 1973. Nearly 70 percent of this material is packaging waste, such as LDPE film, HDPE containers, and PS drinking cups. LDPE and HDPE are the prominant resins in municipal waste, representing 35 percent and 25 percent, respectively, of total waste plastics. Nonpackaging wastes include plastic apparel, luggage, and appliances.

Recycling of municipal plastic waste has been practiced to a limited extent in several source-separation programs in the United States. Citizens in Wellesley, Massachusetts, for example, found a market for mixed-polymer plastic wastes, and were therefore not required to separate the material by resin type. Other programs, however, require separation by polymer.

Most source-separation programs focus on HDPE containers because they can be easily identified, separated, and cleaned by the citizen. The reuse of these containers, however, poses a potential problem. About 50 percent of HDPE scrap is found in detergent and bleach containers, while the other 50 percent is in milk bottles.* The HDPE used in the former is a co-polymer (i.e., it contains other polymer types), whereas the milk bottles use homopolymer HDPE. Certain recycling opportunities (coiled drain pipe, for instance) would preclude the use of homopolymer, but could use the co-polymer.

A major roadblock to economical source separation of plastic wastes, especially containers, is collection. Only one of the 110 source-separation programs monitored by the EPA collects plastics from households. This program (in Austin, Minnesota) collects HDPE containers along with cans, and the two materials are later separated manually. The plastics are then reground and sold to a manufacturer of drainage tubing. Prior to regrinding, however, these plastics are extremely low density, which translates into high collection costs of about 4 cents per pound.

Mechanical separation of plastics from mixed municipal solid waste has been practiced on an experimental basis, primarily by the

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*Based on information provided by an industry representative.

U.S. Bureau of Mines (BOM).[17] BOM has experimented with several different waste mixtures received from the Black Clawson FIBRECLAIM Urban Refuse Recovery System at Franklin, Ohio: moisture, 55 percent by weight; mixed fiber, 30.4 percent; plastic, 14 percent; and metal, 0.6 percent.

The BOM separation system (for which no cost information is available) contains several processing steps, as shown in Figure 7. The two primary plastic separation steps are the electrostatic separator, which separates mixed plastics from the paper fibers, and the hydraulic separator, which separates the plastics by polymer type. As shown in Figure 7, the electrostatic separator yields a 95-percent, plastic-rich fraction.

The hydraulic separator takes advantage of the different densities of the major plastic polymers to achieve separation. Unfortunately, HDPE, LDPE, and PP, known collectively as polyolefins, have approximately the same density and could not be separated by polymer in the BOM process. The results of the hydraulic separation were 3-percent contamination for polyolefin, with other polymers; 5-percent contamination for polystyrene; and 60-percent contamination for PVC.

In other BOM tests, using mixed plastic wastes containing only polyolefins, PS, and PVC, the impurity levels were 0.1 percent for polyolefin; 2.2-3.9 percent for PS; and 0.1-0.4 percent for PVC. These test results indicate that source separation is the only recovery means currently available that meets the secondary resin specification requiring no contamination with other polymers.

POTENTIAL FOR SCRAP PLASTIC USE

The potential for scrap plastic use in construction can be broken down into applications in existing plastic construction products and in new construction products.

Applications in Plastic Construction Products

The feasibility of using secondary resin in construction products depends on two factors. The first is related to the polymer type; the major polymers, in general, differ in their capacity to be recycled. The second is related to the particular product requirements - e.g.,

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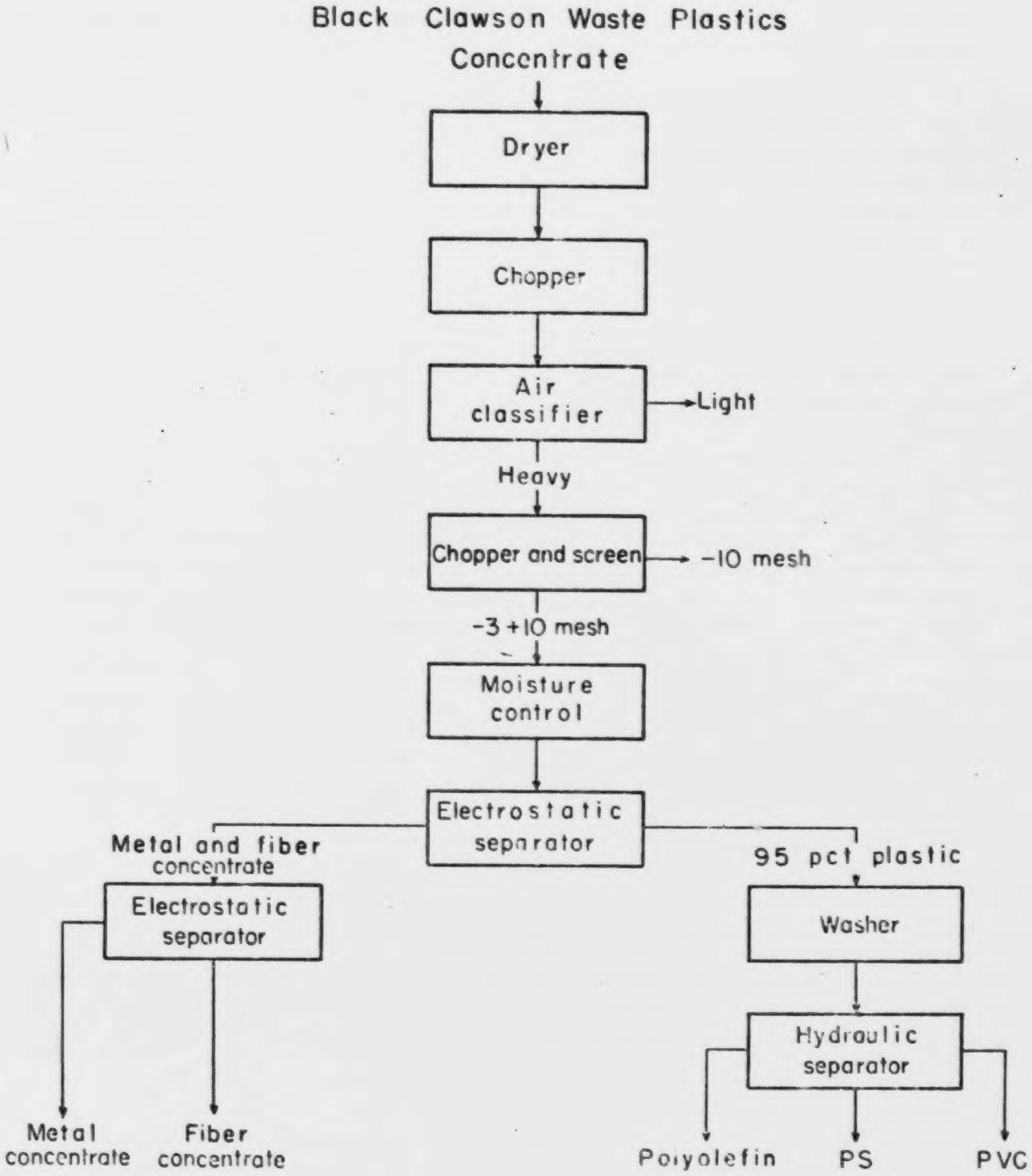
[17] U.S. Bureau of Mines, Recycling of Plastics from Urban and Industrial Refuse, Report of Investigation No. 7955, 1974.

Figure 7

RECOVERING PLASTICS, METAL, AND FIBER FROM BLACK CLAWSON CONCENTRATE


Black Clawson Waste Plastics Concentrate
Dryer
Chopper
Air classifier
Light
Heavy
Chopper and screen
-10 mesh
-3 +10 mesh
Moisture control
Electrostatic separator
Metal and fiber concentrate
95 pct plastic
Electrostatic separator
Washer
Hydraulic separator
Metal concentrate
Fiber concentrate
Polyolefin
PS
PVC

*Source: U.S. Bureau of Mines, Recycling of Plastics from Urban and Industrial Refuse, Department of Investigations No. 7935, 1974.

pressure pipe for gas transmission versus nonpressure pipe for agricultural drainage.

All polymers are sensitive to contamination with other polymers. Different polymers are incompatible with each other, and even when heated and mixed together, they do not blend into a truly homogeneous substance. Boundaries form between the two polymers in the mix, and the boundaries remain when the material sets. These interfaces represent points of weakness in the structure, and, particularly in thin-wall plastic products, could lead to failure at stresses considerably less than expected from virgin material.

Polystyrene and polypropylene are most sensitive to contamination with other polymers; PVC, HDPE, and LDPE are also sensitive, but to a lesser degree than the other two polymers.

The second major problem associated with plastics recycling is that all of the polymers tend to lose or change properties each time they are reheated and reused. PVC has extremely poor heat stability, which impedes its recycling. Polyethylene and polypropylene oxidize and change color with reheating. Additionally, polyethylene flows less readily when remelted, whereas polypropylene flows more readily upon remelting. Polystyrene becomes more opaque each time it is melted.

These property changes can usually be corrected through the use of additives or stabilizers. The major impediment to recycling is that the potential user may not know the heating history of a particular batch of scrap, and is therefore unable to adjust the mix with the proper additives. He would be justifiably concerned about mixing an unknown material with a batch of virgin resin.

To determine to what extent scrap plastic can be applied in plastic construction products, we analyzed the technical potential of nonhome scrap use in pipe, wire and cable, and flooring, three products that consume 80 percent of all thermoplastics used in construction.* (See Table 39.) Table 40 shows the impact of increased scrap use, by polymer type, as a percentage of the resin available in municipal

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*Since the potential for scrap use is directly related to the quality of the scrap, we assumed for the purpose of this analysis that the scrap would not be contaminated with other polymers and only negligibly contaminated with materials such as paper fibers. We also assumed the heat history of the scrap would not be precisely known, but that information would be available on the products (e.g., milk bottles) from which the scrap came.

Table 39

Potential Additional Secondary Resin Use in Construction Plastics

(1000 tons)

Polymer / Product	HDPE	LDPE	PP	PS/ABS	PVC	TOTAL
Pipe (maximum)	51	2	2	64	79	198
Wire and Cable		-	-		-	-
Flooring					53	53
Total	51	2	2	64	132	251

Table 40

Impact of Additional Scrap Use on Municipal Solid Waste

	Potential Scrap Use (1000 tons)	Plastic in Municipal Solid Waste (1000 tons)	Impact (Percent)
HDPE	51	868	6
LDPE	2	1,186	-
PP	2	210	1
PS/ABS	64	618	10
PVC	132	518	25
Total	251	3,400	7

solid waste. Overall, the impact of full substitution on the municipal waste stream ranges from 1 percent (PP) to 25 percent (PVC). (See Table 39.)

Pipe. The major industry specifications for all types of plastic pipe* preclude the use of any nonhome scrap in the manufacture of plastic pipe. This does not mean that the technical limit of outside scrap use is zero. Rather, these specifications are the result of institutional and market factors that are peculiar to the plastic pipe industry.

Secondary plastics, other than "clean rework material generated from the manufacturer's own production," is prohibited in all 13 plastic pipe specifications published by ASTM. These specifications are important because they are followed closely by pipe manufacturers, and are the basis for important Federal specifications for plastic pipe. As described in Chapter II, the Soil Conservation Service Specification for Plastic Drainage Tile and the Soil Conservation Engineering Standard Practice for Drain Tile - Code 606 stipulate that corrugated polyethylene drainage tubing shall conform with the ASTM specification for this material.

The Federal Specification for Polyethylene Pipe, L-P-315C, refers to ASTM D-2239, but a recent change in the Federal specification allows greater flexibility in the reuse of secondary plastics. Section 3.3, Pipe for Other Water, Fluids or Other Use, states: "PE pipe for other than potable water service may include, in addition to clean re-work material, clean rejected or damaged pipe that has not been in service." Thus, a manufacturer could presumably use rejected or damaged pipe originating from another manufacturer.

ASTM specifications preclude nonhome scrap use because of possible polymer contamination from uncertain scrap sources. The manufacturers of plastic pipe have invested substantial resources to convince pipe users that the plastic product is technically as good as the traditional piping materials - copper, clay, steel, concrete. When the industry was in its infancy, there were instances in which manufacturers blended low-quality materials to make pipe that did not meet specifications; but the industry took positive steps at an early date to eliminate this type of practice. One of these steps was to prohibit the use of nonhome scrap. This provision in the ASTM specifications was thus effected by both manufacturers and users of plastic pipe in their mutual desire to maintain the highest possible quality standards.

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*Specifications for plastic products do not help determine technical recycling limits. Rather, plastic specifications are based on physical properties and performance requirements of the particular product. Thus it is difficult to establish a direct linkage between the specification and the technically acceptable scrap content.

To assess the potential for scrap use in plastic pipe, it is first necessary to identify the categories of pipe and the resins used in the manufacture of each. Pipe production is evenly split between pressure and nonpressure applications. (See Table 41.) Approximately 500,000 tons of each are produced per year. PVC comprises 69 percent of pressure pipe; most of the remaining percent is HDPE. In nonpressure applications, PVC and PS/ABS are nearly equal, making up 43 percent and 40 percent, respectively, of the total, while HDPE accounts for about 15 percent.

Specifications and performance requirements are more demanding for pressure pipe than for nonpressure pipe, as might be expected because of the continuing stresses to which pressure pipe is exposed. Additionally, the nature of the materials carried in certain types of pressure piping, such as chemicals and natural gas, requires high performance standards to prevent premature deterioration and/or failure of the pipe.

Agricultural drainage applications (73,000 tons, mostly HDPE) generally demand less stringent quality or performance requirements than other categories. This market is one of the fastest growing areas in the pipe field; a growth rate of 30 percent per year is projected for over the next several years.[18] Indeed, plastic is replacing the market shares of clay and concrete tile, both traditional products in the agricultural drainage area.

Increased scrap usage can be assessed by examining the performance requirements of the various pipe categories and the physical characteristics of the major thermoplastic polymers. Table 42 ranks the feasibility of using secondary

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[18] Chemical Week, October 17, 1973, p. 53.

Table 41

Resin Use in Plastic Pipe - 1973*

(1000 Tons)

PRODUCT / POLYMER	HDPE	LDPE	PP	PS/ABS	PVC	TOTAL
Pressure pipe						
General Purpose	42	22			264	328
Chemical Processing	13				32	45
Irrigation	15				10	25
Gas Distribution	6				14	20
Other			9		26	35
TOTAL Pressure	76	22	9		346	453
Non-Pressure Pipe						
Drain/waste/vent				115	47	162
Conduit	10			20	128	158
Agric. Drain	66			7		73
Sewer				65	48	113
TOTAL Non-Pressure	76			207	223	506
TOTAL	152	22	9	207	569	959

*Source: Chemical Week, October 17, 1973;
Modern Plastics, January 1974;
Resource Planning Associates, estimates.

Table 42

Ranking[1] of Potential for Increased Secondary Resin Utilization*

PRODUCT \ POLYMER	HDPE	LDPE	PP	PS/ABS	PVC
Pressure pipe					
General Purpose	3	4			4
Chemical Processing	4				5
Irrigation	2				3
Gas Distribution	4				5
Other			3		4
Non-Pressure Pipe					
Drain/waste/vent				2	3
Conduit	2			2	3
Agric. Drain	1			1	
Sewer				2	3

[1] Ranking key: 1 - highest potential for increased secondary material utilization.
2
3
4
5 - lowest potential

* Source: Resource Planning Associates, estimates.

plastics (beyond the home scrap used presently) for the various pipe categories, by polymer type. As stated earlier, PVC generally is less suited to recycling than the other polymers because of its poor heat stability.

As shown in Table 42, secondary plastics are more suited to nonpressure applications than to pressure applications because of the continual operating stresses that act on pressurized pipe. Chemical processing and gas-distribution piping have high performance requirements because of the nature of material carried in the pipe and the severe consequences of pipe failure.

Agricultural drainage tubing has been manufactured from post-consumer plastic scrap in at least two cases. Owens-Illinois Corporation sponsored a community project in Wasterville, Ohio, in which 5,000 polyethylene containers were collected for use in drainage tubing. Advanced Drainage of Ohio, Inc., reground the containers and mixed them with virgin material in a 2:3 ratio to make 4,200 feet of 4-inch drainage tile. A similar project was conducted in Southern California by the Golden Arrow Dairy, Dow Chemical Company, and the Ledco Company.

Estimates of increased secondary resin usage are shown in Table 43. The lower figure represents a level of usage immediately feasible if not prohibited by specifications, the higher figure is a maximum level consistent with technical specifications/performance requirements. The substitution range for PVC represents 3-14 percent of PVC pipe production, while the range for HDPE is 10-34 percent. Overall, the substitution potential ranges from 5-19 percent of total plastic pipe production.

In recent months, certain segments of the plastic pipe industry, particularly nonpressure agricultural drainage tubing, which is a relatively low-performance product, have sought a modification of the specifications to allow greater secondary plastic usage. Pressure from resin shortages and rising prices, plus the fact that drainage application does not require the highest grade of materials, has forced manufacturers to consider outside sources of scrap.

Positive action in this direction was taken at a recent ASTM Plastic Pipe Committee meeting (June 1974), when the members made a formal request to the Test Methods Subcommittee to develop new test methods for drainage tubing.

Table 43

Potential Additional Secondary Resin Use in Plastic Pipe - 1973*

(1000 tons)

POLYMER / PRODUCT	HDPE		LDPE		PP		PS/ABS		PVC		TOTAL	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Pressure Pipe												
General purpose	2	8	-	2					5	26	7	36
Chemical processing	-	1							-	2	-	3
Irrigation	2	5							1	2	3	7
Gas Distribution	-	1							-	1	-	2
Other					1	2			1	3	2	5
TOTAL Pressure	4	15	-	2	1	2			7	34	12	53
Non-Pressure Pipe												
Drain/waste/vent							12	34	2	9	14	43
Conduit	1	3					2	6	6	26	9	35
Agric. Drain	10	33					1	4			11	37
Sewer							7	20	2	10	9	30
TOTAL Non-Pressure	11	36					22	64	10	45	43	145
TOTAL	15	51	-	2	1	2	22	64	17	79	55	198

*Source: Resource Planning Associates, Inc. estimates.

These methods would enable a manufacturer to test a plastic scrap source, and to determine what percentage, if any, could be used in his manufacturing operation.

Wire and cable. Plastic is used as the insulation material for wire and cable products. LDPE accounts for 48 percent of this material, PVC comprises 41 percent, and PP constitutes the remainder. These insulating materials have strict physical requirements; they are thin-walled and must have enough strength and flexibility to resist any stress cracking over the life of the wire or cable product. Performance requirements for this material are among the most demanding of any plastic product.

Manufacturers currently use only virgin resin in the manufacture of wire and cable insulation; home scrap is rarely used. It is therefore concluded that this is not a good opportunity for using recycled scrap plastic.

Flooring. Flooring, which uses the PVC polymer, regularly contains up to 50 percent recycled home scrap, but manufacturers are hesitant to use any scrap from sources other than their own plants. A major manufacturer of vinyl-asbestos tile indicated that a number of potential technical problems relate to the use of outside scrap. Specifically, color is extremely important in the tile business, so clear, water-white material is a must. In addition, additives in the scrap could affect some or all of the following properties: color retention, staining, fire resistance, adhesion to backing, adhesion of the wear layer, aging, and dimensional stability.

Notwithstanding the technical problems of uncertain scrap sources, there is an opportunity in flooring to use secondary industrial or post-consumer resin. In fact, the above-mentioned manufacturer is investigating the use of purchased scrap for tile manufacture. It is estimated that 25 percent nonhome scrap could be used in vinyl and vinyl-asbestos tile, provided the scrap were clean and uniform, and previous additives could be identified. This amounts to 53,000 tons of PVC scrap of the total 1973 tile production of 211,000 tons.

Applications in New Construction Products

In light of the technical problems of separating polymers for reuse in existing plastic products, considerable interest has recently been generated in using mixed-polymer plastic waste for new types of products. Since polymer mixing degrades the strength and durability of plastic products, particularly thin-wall materials, the new mixed-polymer products typically are thick-walled (one-half inch thick or greater) and are not subject to the stress levels that are safe for virgin resins.

These new construction applications for mixed waste plastics include highway base material, wood substitutes, and sand substitute in concrete, each of which is discussed in some detail below.

> Highway base material. The highway base material application was developed on an experimental basis in Germany. It was found that plastic improved the insulating properties of the base material, thereby reducing temperature cracking during cold weather. No cost information is yet available on this application.
>
> Wood substitutes. Several Japanese firms have experimented with - and, in some cases developed on a pilot or commercial sale - processes to make wood substitutes from low-grade mixed plastic scrap. Mitsubishi Petrochemical Company, one of Japan's two top plastic resin producers, has developed a reprocessing machine called Reverzer. This machine can reportedly rework any mixture of PE, PP, PS, ABS, PVC, and other resins in any input form. Also, depending upon end-use product specifications, the system can accept up to 50-percent nonplastic materials, such as sand, glass, paper, and textiles.[19] There are 25 Reverzers operating in Japan.
>
> The two wood-substitute construction products that can be made in the process are fence posts and lumber (e.g., 2 x 4's). Capital costs for the process are $100,000 to $150,000 for the equipment, plus the costs of a building and utilities. Production of simpler products, such as the fence posts, reportedly costs about 16 cents per pound.[20]

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[19] Modern Plastics, February, 1971.

[20] Ibid.

There is no published information available either on the technical performance or appearance of these products, or on their *market acceptance*. However, given the available information, it is possible to analyze the economic attractiveness of these products relative to their wood counterparts, and to identify some of the major problems of marketing these products in the United States.

Assuming these products have a density approximating that of most virgin resins (60 lb./cubic foot), the production cost of 16 cents per pound is equivalent to 58 cents per board-foot. (For 2 x 4's, one board-foot equals 0.06 cubic foot.) In the United States, Southern Pine 2 x 4's wholesale selling price in Boston in June 1974 was 23 cents per board-foot. Thus, the wholesale selling *price* of the wood product is less than 40 percent of the manufacturing *cost* of the plastic substitute.

Although fencing is not sold by the board-foot, it is priced about the same as lumber, on a unit volume basis. Thus, the Reverzer economics are apparently extremely unfavorable when compared with U.S. prices of lumber and fencing. However, because wood is much less plentiful in Japan than in the U.S., it is possible that Reverzer is competitive with Japanese wood prices.

Beyond the issue of unfavorable economics is the question of marketing these products in the U.S. and the likelihood of acceptance by the various market segments. Major barriers to market acceptance are:

> *Weight*. If the wood substitutes were not foamed to a density less than 60 lb./cubic foot (as they apparently are not with Reverzer), then their density would be nearly *twice* that of wood (i.e., 30 lb./cubic foot). For lumber products particularly, this increased weight would lead to higher installation costs and certain labor resistance.
>
> *Appearance*. Most wooden fencing in the U.S. is purchased by homeowners for decorative purposes. Appearance and a "quality" image are undoubtedly important to the buyer. The plastic substitute would probably have neither the appearance nor the quality image of wood.

Building codes. The lumber substitute would probably not be accepted by local building code officials across the country because of toxic combustion products given off when some plastics burn.

Sand substitute in concrete. The Society of the Plastics Industry and Hoffer Plastics Corporation (South Elgin, Illinois) cooperated in a project to use plastic chips as a replacement for sand in a concrete bridge. Tests conducted by the Portland Cement Association (PCA) showed that plastic-containing concretes do not match regular concretes either in economics or in strength and workability. Regarding strength and workability, PCA concluded:[21]

- Workability is reduced and cannot be effectively restored by the addition of greater than usual amounts of water.
- Thermal expansion is greatly increased.
- Compressive and split tensile strengths are reduced at all ages through 1 year.
- Modulus of rupture is greatly reduced after the concrete has received moderate temperature cycling.
- Shrinkage is only slightly reduced at the later ages.
- Creep is significantly increased, particularly in lightweight concrete with high levels of sand replacement by plastic scrap.

POTENTIAL FEDERAL IMPACTS

The Federal Government purchases 220 million square feet of flooring (all types) and 65,000 tons of plastic pipe. (See Table 44.) Direct procurement consumes about 30 percent of flooring, but only 6 percent of plastic pipe. The major purchasing agencies of these two items are the Department of Health, Education, and Welfare (flooring), and the Department of Agriculture (plastic pipe). The Department of

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[21] Portland Cement Association, Final Report on Evaluation of Ground Plastic Scrap as a Partial Sand Replacement in Concrete, 1972.

Table 44

Federal Procurement of Flooring And Plastic Pipe

	Total Direct	Total Indirect	Total Federal	Major Agency
Flooring (MMSF)	71	149	220	95[1]
Plastic Pipe (000 tons)	3	62*	65*	33*[2]

*Includes 33,000 tons not shown on Table 11 - Soil Conservation Service, Department of Agriculture, strongly influences the purchase of plastic agricultural drainage tubing, although it does not fund construction.

[1] Department of Health, Education and Welfare

[2] Department of Agriculture

Agriculture's Soil Conservation Service (SCS)* influences the procurement of about 50 percent of the nation's agricultural drainage tubing through technical assistance programs to farmers and farm groups. (No construction funds are provided.) This amounts to about 33,000 tons of plastic pipe annually.

The additional tonnage of PCW plastic that could be used in these two plastic products purchased (or influenced) by the Government amounts to 13,700 tons of flooring and 22,900 tons of plastic pipe. (See Table 45. These tonnages are based on the waste substitution potentials developed previously in this section.) Thus, the maximum Federal impact is 36,600 tons, or about 1.1 percent of municipal solid-waste (MSW) plastics. The SCS alone could influence the use of 16,500 tons of plastic scrap, or about 0.5 percent of all MSW plastics.

***

In summary, our analysis of the feasibility of increased use of secondary plastics in construction products shows that:

1. The availability of scrap plastic is a major constraint to its extensive use in construction products.
    a. The current technology for separating plastic from mixed municipal refuse produces a low-quality resin unsuitable for use as secondary resin.
    b. Source separation is feasible, but polymer identification may be difficult.
    c. Energy-recovery value of plastics is strong competition for material recovery.
2. Recycling opportunities in existing products have small impact on the municipal solid waste stream. The total national potential for pipe and flooring is 251,000 tons, of 7 percent of MSW plastics. Of this amount, the total Federal share would amount to 36,600 tons.
3. Industry resistance to using nonhome scrap is eroding.

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*SCS officials are active members of the ASTM plastic pipe committees and are closely involved with the suggested changes to the ASTM specification, which would allow secondary resin use in agricultural drainage tubing.

Table 45

Potential Use of PCW Plastic In Federal Construction*

(000 Tons/Year)

	Total Direct	Total Indirect	Total Federal	Major Agency
Flooring	4.4	9.3	13.7	5.9[1]
Plastic Pipe	0.6	22.3	22.9	16.5[2]
Total	5.0	31.6	36.6	22.4

[1] Department of Health, Education and Welfare

[2] Department of Agriculture

*Source: Resource Planning Associates estimate

    a. Virgin resin price increases and shortages are forcing the industry to consider ways of using all available resin.

    b. Pressure is building in the plastic pipe industry to delete the nonhome scrap prohibition from the ASTM specifications, especially for agricultural drainage tubing.

4. New construction products made from mixed-polymer wastes are not viable opportunities.

D. PAPER

USES OF PAPER IN CONSTRUCTION

As shown in Table 46, construction paper and board production in 1972 amounted to 5.19 million tons, or 9 percent of total paper and board production. The major categories of construction paper and board are construction paper, gypsum linerboard, insulating board, and hard pressed board. Other construction uses of paper include loose-fill insulation and bituminous fiber pipe and conduit. The latter product is used for sewer and drain lines and as electrical conduit, and is made from recycled newsprint saturated with a bituminous coating.

From a paperstock-consumption standpoint, both loose-fill insulation and bituminous fiber pipe and conduit use 100 percent obsolete paperstock - i.e., newsprint. (See Table 47.) In the paper and board category, gypsum linerboard uses a 100-percent paperstock furnish, of which 63 percent is obsolete; hard pressed board uses no paperstock; and construction paper and insulation board each use 47 percent paperstock - 32 percent obsolete and 15 percent home and prompt.

Paperstock grades for the paper and board construction products are generally lower than for other paper and board products. It is estimated[22] that the paperstock used in construction paper and

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[22] American Paper Institute, Paper, Paperboard, and Woodpulp Capacity 1971-1974.

Table 46

Production of Construction Paper and Board - 1972*

(Million Tons)

Paper and Board[1]	
Construction Paper and Board	
Construction Paper	1.92
Gypsum Linerboard	1.05
Insulating Board (used in building construction)	1.27
Hard Pressed Board (used in building construction)	0.95
Total Construction Paper and Board	5.19
Other Paper and Board	54.27
Total Paper and Board	59.46
Other Construction Uses of Paper	
Loose Fill Insulation	Less than 0.05
Bituminous Fiber Pipe and Conduit	0.05

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[1] As classified in U.S. Department of Commerce *Current Industrial Reports*

*Source: U.S. Department of Commerce, *Current Industrial Reports,* Pulp, Paper, and Board 1972.

Midwest Research Institute, *The Role of Non-Packaging Paper in Solid Waste Management.*

Resource Planning Associates estimates.

Table 47

Paperstock Use in Paper Construction Products - 1972*

	Production (MM Tons)	Home & Prompt Paperstock		Obsolete Paperstock		Total Paperstock	
		Percent	MM Tons	Percent	MM Tons	Percent	MM Tons
Construction Paper and Board							
Construction Paper	1.92	15	0.29	32	0.61	47	0.90
Gypsum Linerboard	1.05	37	0.39	63	0.66	100	1.05
Insulating Board	1.27	15	0.19	32	0.41	47	0.60
Hard Pressed Board	0.95	-	-	-	-	-	-
Total Construction Paper & Board	5.19	17	0.87	32	1.68	49	2.55
Loose Fill Insulation	Less than 0.05	-	-	100	N/A	100	N/A
Bituminous Fiber Pipe and Conduit	0.05	-	-	100	0.05	100	0.05

*Source: American Paper Institute, Paper, Paperboard, and Woodpulp Capacity, 1971-1974.

Resource Planning Associates estimates.

insulation board has the following mix: mixed, 58 percent; newsprint, 21 percent; corrugated, 12 percent; and pulp substitute, 9 percent.

PAPERSTOCK SUPPLY

Paper is the major component of municipal solid waste, accounting for approximately 39 million tons, or 31 percent of the 125-million-ton municipal waste stream in 1971.[23] Of this, an estimated 8 million tons was recycled; thus, 31 million tons was discarded.*

Most paper recycling is accomplished through source-separation programs, which tend to focus primarily on newsprint. Mechanical separation of paper from mixed refuse has been demonstrated in the U.S. and abroad. The Black Clawson system in Franklin, Ohio, includes a wet separation system for paper fibers, while a European concern, Krauss-Maffei, has developed a dry processing system for paper separation. (The outputs from the Black Clawson system are currently being used in a construction application - roofing felts.)

POTENTIAL FOR ADDITIONAL PAPERSTOCK USE

To determine to what further extent recycled paper can be used in construction products, we examined the technical and institutional problems related to increased paperstock usage in construction paper, insulation board, and hard pressed board.

Construction Paper

Eighty-one percent of construction paper is used in roofing felts, which are saturated with asphalt in the manufacturing process. Industry officials indicate that a roofing felt made of 100 percent recycled fibers (versus the present composition of 50 percent recycled fiber and 50 percent pulp from wood waste) would meet all existing technical performance requirements. The problem with using more paperstock lies in the manufacturing operation.

Roofing felts are manufactured in a wet processing system. Higher paperstock usage slows drainage and drying of the finished product, thereby slowing the entire production process.

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* Resource Planning Associates estimates.

[23] Dr. John H. Skinner, "Resource Recovery: The Federal Perspective," Waste Age, January/February 1974, p. 12.

A related, and more serious problem, is absorption of asphalt. Product requirements demand a given quantity of asphalt per square foot. The higher absorption of recycled fibers means greater retention of asphalt, which leads to excess roofing weight and wastage of the asphalt.

"Deadening felt" is a type of building felt made without asphalt, and industry sources indicate that a 60-percent paperstock usage would be acceptable, from a manufacturing point of view, in this material. Fifty percent is considered to be the desired paperstock level for asphalt-saturated felts.

Insulation Board

Insulation board is subject to the same types of manufacturing constraints as construction paper. From a product performance point of view, 100 percent newsprint would be acceptable. However, the drainage problem and the asphalt retention problem (in the case of asphalt-impregnated exterior insulation board) limit recycling levels to about 50 percent.

Hard Pressed Board (Hardboard)

Except for a small portion of the total production, hardboard uses no paperstock. There are important technical and institutional factors that explain why hardboard is traditionally manufactured without paperstock. Most important is the location of hardboard mills. These are located primarily in the Northwest and Southeast, close to lumber mills on which they rely for the necessary wood wastes. These locations are typically in remote areas and are not logistically well suited to the use of paperstock, which is generated in populated areas.

The technical constraint to using recycled fibers in hardboard is that for many years the wet process was used exclusively. Similar to construction paper and insulation board, the slow drainage associated with paperstock use discouraged manufacturers from using recycled materials.

Dry-process plants are becoming more popular, however, because of the lower capital investment requirements and the absence of water pollution problems that plague the wet-process plants. Dry processing uses a hot press to compress the fibrous material into hardboard. Resin is used as a bonding agent, and more resin is required when paperstock is used than when virgin materials are used.

The U.S. Forest Products Laboratory experimented with a dry-process hardboard containing 100 percent paperstock. It was found that three times as much resin was required than when no paperstock was used. However, because resin is a petroleum-based product, the recent oil-price increases could act as a significant economic disincentive for recycled fiber use.

Two firms - Homasote Company of Trenton, New Jersey, and Upson Company of Lockport, New York - currently make a "medium density" hardboard from 100 percent recycled newsprint. These products apparently meet the required technical specifications.

Since it is technically feasible, from a product performance standpoint, to use 100 percent recycled fibers in construction paper, insulation board, and hardboard, it is appropriate to measure the impact of full substitution, in terms of increased paperstock use. For the three products, full substitution would amount to 2.64 million tons of paperstock, using the 1972 figures presented in Table 42. This would amount to about 9 percent of the 31 million tons of paper remaining in the municipal solid waste stream after recycling at current rates.

POTENTIAL FEDERAL IMPACTS

At present, Federal purchases of construction paper, or of construction products that could contain paper, amount to 181 million square feet of waterproofing materials (e.g., construction paper), 167 million square feet of insulation materials (e.g., insulating board), and 624 million square feet of wall-surfacing materials (e.g., hardboard). (See Table 48.) The major Government purchaser of these materials is the Department of Health, Education, and Welfare, which accounts for 30-40 percent of total Federal consumption.

But the Federal Government could purchase an additional 455,000 tons of wastepaper, or about 1.5 percent of the paper remaining in the municipal waste stream after recycling at current rates. (See Table 49.) The purchases of the Department of Health, Education, and Welfare alone could account for an additional 173,000 tons of wastepaper, or 0.5 percent of the paper in the waste stream. And, indeed, the Federal Government has already taken steps to increase the recycling of construction paper and board through the procurement process. Specifically, the GSA has developed specifications for construction paper and insulating board. which have the following recycled material requirements:

Table 48

Federal Procurement of Construction Materials That Could Contain Waste Paper (MMSF)

	Total Direct	Total Indirect	Total Federal	Major Agency
Waterproofing	48	133	181	66.2[1]
Insulation	45	122	167	66.2[1]
Wall Surfacing	195	429	624	237[1]

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[1] Department of Health, Education and Welfare

Table 49

Potential Additional Use of Wastepaper In Federal Construction

(Million Tons/Year)

	Total Direct	Total Indirect	Total Federal	Major Agency
Waterproofing (Construction Paper)	0.002	0.005	0.007	0.002
Insulation (Insulating Board)	0.016	0.042	0.058	0.023
Wall Surfacing (Hardboard)	0.122	0.268	0.390	0.148
Total	0.14	0.315	0.455	0.173

	Percent Reclaimed Material	Percent PCW
Roofing Felt (construction paper)	40	30
Insulation (insulation board)	15	

***

In summary, our analysis of the feasibility of increasing the use of recycled paper in construction products shows that:

1. It is technically feasible to use more recycled fibers in paper construction products. The maximum incremental recycling would amount to 2.64 million tons for construction paper, insulation board, and hardboard, or approximately 5 percent of the paper fibers in the municipal solid waste stream. Of this amount, the total Federal share would represent 0.46 million tons.
2. There are technical (i.e., type of manufacturing process) and institutional (i.e., location of hardboard plants) constraints to using more paperstock.

* * *

Overall, in assessing the extent to which the four municipal waste materials - ferrous, glass, plastics, and paper - can be recycled and utilized in construction products, we conclude:

- Significant opportunities do exist to use additional waste materials in construction products.
- In terms of impact on the municipal solid waste stream, the ferrous and glass product opportunities are the most attractive. Federally-purchased construction products could utilize at least 8 percent of the ferrous containers in the waste stream and more than 12 percent of waste glass containers. The potential Federal impact on plastic and paper wastes, on the other hand, would amount to only 1-2 percent of the tonnages of these materials in municipal waste.

- Waste supply is a major constraint to increased use of waste glass and plastics in construction products. Most of the glass opportunities are economically viable only with the lower value cullet from resource recovery systems, and plastics are difficult to separate - even in the home - because of the wide variety of plastic polymers.

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APPENDIX A

FEDERAL CONSTRUCTION PROGRAMS

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ARCHITECT OF THE CAPITOL

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	88
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	19
Brick	9
Steel (000 tons)	
Structural	
Reinforcing	4
Miscellaneous	
Flat Glass (000 tons)	1.4
Waterproofing (MMSF = million square feet)	0.6
Insulation (MMSF)	0.6
Roofing (MMSF)	0.6
Wall Covering (MMSF)	3
Floor Covering (MMSF)	1.4
Wire (000 tons)	
Copper	0.016
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	0.24
Concrete	
Clay	
Copper	0.012
Asbestos-Cement	
Plastic	0.012
Steel	

Program Description:

Capitol buildings (direct)

Fiscal Year 1973 Funding:

$33 million

Guide Specifications:

Developed on case-by-case basis

Contact:

Coordinating Engineer

Percent Design by Outside A-E: 65%

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DEPARTMENT OF AGRICULTURE - 1

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	643
Bituminous Concrete (000 tons)	1,170
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	11
Reinforcing	10
Miscellaneous	6
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	1
Concrete	58
Clay	12
Copper	
Asbestos-Cement	1
Plastic	
Steel	2

Program Description:

Forest Service - Roads, wastewater treatment facilities (direct)

Fiscal Year 1973 Funding:

$201 million

Guide Specifications:

Forest Service Standard Specifications for Construction of Parks and Bridges

Contact:

Division of Engineering, Engineering Operations Management

Percent Design by Outside A-E: 100%

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	338
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	18
Reinforcing	5
Miscellaneous	
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	
Concrete	650
Clay	286
Copper	
Asbestos-Cement	38
Plastic	4
Steel	

Program Description:

Farmers Home Administration - Rural waste disposal facilities grants and loans (indirect)

Fiscal Year 1973 Funding:

Federal - $736 million

Total - $754 million

Guide Specifications:

No material specifications; general guidelines to assure economic feasibility and compliance with minimum health and safety standards

Contact:

Deputy Administrator, Program Operations Department, Community Services Water and Waste Disposal Loan Division

Laws:

Consolidated Farmers Home Administration Act of 1961, as amended; Rural Water Facilities Act of 1965, PL 89-240; Consolidated Farm and Rural Development Act of 1972, PL 92-419.

DEPARTMENT OF AGRICULTURE - 3

Program Summary

FY 1973 Construction Material Purchases

- Portland Cement Concrete (000 tons)
- Bituminous Concrete (000 tons)
- Masonry (000 tons)
  - Concrete Block
  - Brick
- Steel (000 tons)
  - Structural
  - Reinforcing
  - Miscellaneous
- Flat Glass (000 tons)
- Waterproofing (MMSF = million square feet)
- Insulation (MMSF)
- Roofing (MMSF)
- Wall Covering (MMSF)
- Floor Covering (MMSF)
- Wire (000 tons)
  - Copper
  - Aluminum
  - Insulation - Plastic
- Pipe (000 tons)
  - Cast Iron
  - Concrete
  - Clay
  - Copper
  - Asbestos-Cement
  - Plastic
  - Steel

(Negligible)

Program Description:

Soil Conservation Service - Flood prevention and watershed protection loans and grants (indirect)

Fiscal Year 1973 Funding:

Federal - $115 million

Total - $158 million

Guide Specifications:

SCS National Engineering Handbook - Section 20. Although most funded projects involve negligible construction materials (as seen at left) SCS also provides engineering guidance for other non-funded projects, such as agricultural drainage. Their specifications figure importantly in these projects.

Contact:

Deputy Administrator, Water Resources Department, Engineering Division

Laws:

Watershed Protection and Flood Prevention Act as amended.

DEPARTMENT OF AGRICULTURE - 4

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	
Reinforcing	
Miscellaneous	
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	13.6
Aluminum	35.8
Insulation - Plastic	11
Pipe (000 tons)	
Cast Iron	
Concrete	
Clay	
Copper	
Asbestos-Cement	
Plastic	
Steel	

Program Description:

Rural Electrification Administration - Rural electric and telephone systems loans (indirect)

Fiscal Year 1973 Funding:

Federal - $763 million

Total - $1,270 million

Guide Specifications:

Bulletins 43-5 and 344-2 are "acceptable" materials lists for the electric and telephone projects, respectively

Contact:

Electric Division: Deputy Administrator, Standards Division for Electric Projects

Telephone Division: Assistant Director, Standards Division for Telephones

Laws:

Rural Electrification Act of 1936, Titles I and II, as amended

U.S. ARMY CORPS OF ENGINEERS, CIVIL WORKS

Program Summary

FY 1973 Construction Material Purchases

Portland Cement Concrete (000 tons)	10,372
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	121
Reinforcing	84
Miscellaneous	
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	
Concrete	
Clay	
Copper	
Asbestos-Cement	
Plastic	
Steel	

Program Description:

Civil works projects for flood control, navigation, power supply (direct)

Fiscal Year 1973 Funding:

$1,221 million

Guide Specifications:

U.S. Corps of Engineers Guide Specifications for Civil Works Construction

Contact:

Office of the Chief of Engineers, Directorate of Civil Works

Percent Design by Outside A-E: 20%

DEPARTMENT OF COMMERCE

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	286
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	62
Brick	30
Steel (000 tons)	
Structural	
Reinforcing	12
Miscellaneous	
Flat Glass (000 tons)	4.4
Waterproofing (MMSF = million square feet)	2.1
Insulation (MMSF)	2.1
Roofing (MMSF)	2.1
Wall Covering (MMSF)	11
Floor Covering (MMSF)	4.7
Wire (000 tons)	
Copper	0.052
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	62.78
Concrete	
Clay	34
Copper	0.039
Asbestos-Cement	
Plastic	3.939
Steel	

Program Description:

Economic Development Administration - Commerce and transportation facilities grants and loans (indirect)

Fiscal Year 1973 Funding:

Federal - $220 million

Total - $376 million

Guide Specifications:

No guide specifications.

Contact:

Director, Office of Public Works.

Laws:

Public Works and Economic Development Act of 1965, as amended.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE - 1

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	68
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	15
Brick	8
Steel (000 tons)	
Structural	2
Reinforcing	2
Miscellaneous	
Flat Glass (000 tons)	1
Waterproofing (MMSF = million square feet)	.4
Insulation (MMSF)	.4
Roofing (MMSF)	.4
Wall Covering (MMSF)	3
Floor Covering (MMSF)	1
Wire (000 tons)	
Copper	.01
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	.06
Concrete	
Clay	
Copper	.03
Asbestos-Cement	
Plastic	.03
Steel	

Program Description:

Indian Health Facilities (direct)

Fiscal Year 1973 Funding:

$45 million

Guide Specifications:

Guide Specifications for Construction

Contact:

Director, Office of Architectural and Engineering Services, Facilities Engineering and Construction Branch

Percent Design by Outside A-E: 90%

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE - 2

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	387
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	82
Brick	41
Steel (000 tons)	
Structural	22
Reinforcing	15
Miscellaneous	
Flat Glass (000 tons)	3.4
Waterproofing (MMSF = million square feet)	5
Insulation (MMSF)	5
Roofing (MMSF)	5
Wall Covering (MMSF)	16
Floor Covering (MMSF)	7
Wire (000 tons)	
Copper	0.036
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	2.0
Concrete	
Clay	
Copper	0.1
Asbestos-Cement	
Plastic	0.08
Steel	

Program Description:

Health Professions Facilities Grants (indirect)

Fiscal Year 1973 Funding:

Federal - $50 million

Total - $149 million

Guide Specifications:

No material specifications; general guidelines for health and environmental standards

Contact:

Director of Facilities Engineering and Property Management, Health Facilities Planning

Laws:

Public Health Service Act, PL 88-129, Title III, Part B, Section 720-729; Comprehensive Health Manpower Act of 1971

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE - 3

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	86
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	18
Brick	9
Steel (000 tons)	
Structural	5
Reinforcing	3
Miscellaneous	
Flat Glass (000 tons)	0.8
Waterproofing (MMSF = million square feet)	1
Insulation (MMSF)	1
Roofing (MMSF)	1
Wall Covering (MMSF)	4
Floor Covering (MMSF)	1
Wire (000 tons)	
Copper	0.008
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	0.4
Concrete	
Clay	
Copper	0.02
Asbestos-Cement	
Plastic	0.02
Steel	

Program Description:

Nursing Construction Grants (indirect)

Fiscal Year 1973 Funding:

Federal - $20 million

Total - $43 million

Guide Specifications:

No material specifications; guidelines for health and environmental standards

Contact:

Director, Office of Architecture and Engineering

Laws:

Public Health Services Act, Title III, Section 801, PL 90-490, 78-410, as amended.

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE - 4

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	68
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	15
Brick	8
Steel (000 tons)	
Structural	2
Reinforcing	2
Miscellaneous	
Flat Glass (000 tons)	1
Waterproofing (MMSF = million square feet)	.4
Insulation (MMSF)	.4
Roofing (MMSF)	.4
Wall Covering (MMSF)	3
Floor Covering (MMSF)	1
Wire (000 tons)	
Copper	.01
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	.06
Concrete	
Clay	
Copper	0.03
Asbestos-Cement	
Plastic	0.03
Steel	

Program Description:

National Institutes of Health - Cancer research grants (indirect)

Fiscal Year 1973 Funding:

Federal - $33 million

Total - $44 million

Guide Specifications:

No material specifications; guidelines for health and environmental standards

Contact:

Office of Architecture and Engineering, Director, Health Research Facilities and Resources Branch, Health Facilities Construction Division

Laws:

National Cancer Act of 1971, PL 92-218, as amended

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE - 5

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	3,311
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	702
Brick	354
Steel (000 tons)	
Structural	185
Reinforcing	132
Miscellaneous	
Flat Glass (000 tons)	29.3
Waterproofing (MMSF = million square feet)	48
Insulation (MMSF)	48
Roofing (MMSF)	48
Wall Covering (MMSF)	140
Floor Covering (MMSF)	57
Wire (000 tons)	
Copper	0.308
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	16.9
Concrete	
Clay	
Copper	0.86
Asbestos-Cement	
Plastic	0.68
Steel	

Program Description:

Office of Education - Grant and loan subsidies (indirect)

Fiscal Year 1973 Funding:

Federal - $560 million

Total - $1,428 million

Guide Specifications:

No specifications

Contact:

Division of Academic Facilities, Operations Branch

Laws:

Higher Education Act of 1965, Title VII, as amended

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE - 6

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	2,006
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	449
Brick	236
Steel (000 tons)	
Structural	72
Reinforcing	46
Miscellaneous	
Flat Glass (000 tons)	22
Waterproofing (MMSF = million square feet)	11.8
Insulation (MMSF)	11.8
Roofing (MMSF)	11.8
Wall Covering (MMSF)	74
Floor Covering (MMSF)	29
Wire (000 tons)	
Copper	.43
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	17.7
Concrete	
Clay	
Copper	0.87
Asbestos-Cement	
Plastic	0.74
Steel	

Program Description:

Hill-Burton hospital grants and loans (indirect)

Fiscal Year 1973 Funding:

Federal - $158 million

Total - $1,191 million

Guide Specifications:

No material specifications; Minimum Requirements of construction and Equipment for Hospital and Medical Facilities

Contact:

Director of Facilities Engineering and Property Management, Health Facilities Planning

Laws:

Public Health Service Act, Title VI, PL 91-296

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT - 1

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	
Reinforcing	
Miscellaneous	
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	118
Concrete	
Clay	64
Copper	
Asbestos-Cement	
Plastic	7.6
Steel	

Program Description:

Community Development - Public Facilities Loans and Water and Sewer Grants (Indirect)

Fiscal Year 1973 Funding:

Federal - $177 million

Total - $503 million

Guide Specifications:

Minimum Design Standards for Community Water Supply Systems, Circular #4940.2;
Minimum Design Standards for Community Sewage Systems, Circular $4940.3

(Both discuss materials generally - no specifics)

Contact:

Community Development Department, Office of Program Services; Director, Program Regulations and Assistance Division

Laws:

Housing Amendments of 1965, Title II, as amended, PL 84-345; Housing and Urban Development Act of 1965, Title VII, Section 702, as amended, PL 89-117

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	198
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	43
Brick	21
Steel (000 tons)	
Structural	
Reinforcing	8
Miscellaneous	
Flat Glass (000 tons)	3.1
Waterproofing (MMSF = million square feet)	1.4
Insulation (MMSF)	1.4
Roofing (MMSF)	1.4
Wall Covering (MMSF)	8
Floor Covering (MMSF)	3.2
Wire (000 tons)	
Copper	0.036
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	0.54
Concrete	
Clay	
Copper	0.027
Asbestos-Cement	
Plastic	0.027
Steel	

Program Description:

Community Development - Neighborhood Facilities Grants (indirect)

Fiscal Year 1973 Funding:

Federal - $40 million

Total - $80 million

Guide Specifications:

No specifications

Contact:

Community Development Department, Office of Program Services; Director, Program Regulations and Assistance Division

Laws:

Housing and Urban Development Act of 1965, Title VII, Section 703, PL 89-117

Program Summary

FY 1973 Construction Material Purchases

Portland Cement Concrete (000 tons)	1,564
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	218
Brick	298
Steel (000 tons)	
Structural	47
Reinforcing	42
Miscellaneous	
Flat Glass (000 tons)	27.2
Waterproofing (MMSF = million square feet)	19.6
Insulation (MMSF)	19.6
Roofing (MMSF)	11.5
Wall Covering (MMSF)	111
Floor Covering (MMSF)	42
Wire (000 tons)	
Copper	0.47
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	6.7
Concrete	
Clay	
Copper	0.34
Asbestos-Cement	
Plastic	0.272
Steel	

Program Description:

Low-rent public housing loans (indirect)

Fiscal Year 1973 Funding:

Federal - $900 million

Total - $900 million

Guide Specifications:

Minimum Property Standards - 4900.1, 4910.1, 4920.1 - Some discussion of material requirements is included

Contact:

Office of Subsidized Housing Programs; Director, Publically Financed Housing Division

Laws:

U.S. Housing Act of 1937, as amended, PL 75-412; Housing and Community Development Act of 1974, Section VII

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	92
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	13
Brick	18
Steel (000 tons)	
Structural	3
Reinforcing	2
Miscellaneous	
Flat Glass (000 tons)	1.6
Waterproofing (MMSF = million square feet)	1.2
Insulation (MMSF)	1.2
Roofing (MMSF)	0.7
Wall Covering (MMSF)	7
Floor Covering (MMSF)	2
Wire (000 tons)	
Copper	.03
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	0.4
Concrete	
Clay	
Copper	0.02
Asbestos-Cement	
Plastic	0.016
Steel	

Program Description:

College housing loans (indirect)

Fiscal Year 1973 Funding:

Federal - $50 million
Total - $50 million

Guide Specifications:

No specifications

Contact:

Office of Subsidized Housing Programs;
Chief, College Housing Branch

Laws:

Housing Act of 1950, Title IV, as amended, PL 81-475

DEPARTMENT OF THE INTERIOR - 1

Program Summary

FY 1973 Construction Material Purchases

Portland Cement Concrete (000 tons)	5,928
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	79
Reinforcing	46
Miscellaneous	
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	
Concrete	
Clay	
Copper	
Asbestos-Cement	
Plastic	
Steel	

Program Description:

Bureau of Reclamation - Irrigation, reclamation projects (direct)

Fiscal Year 1973 Funding:

$380 million

Guide Specifications:

Specifications prepared on case-by-case basis

Contact:

Chief, Division of General Engineering

Percent Design by Outside A-E: 0%

DEPARTMENT OF THE INTERIOR - 2

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	129
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	27
Brick	14
Steel (000 tons)	
Structural	7
Reinforcing	5
Miscellaneous	
Flat Glass (000 tons)	1.1
Waterproofing (MMSF = million square feet)	2
Insulation (MMSF)	2
Roofing (MMSF)	2
Wall Covering (MMSF)	5
Floor Covering (MMSF)	2
Wire (000 tons)	
Copper	0.012
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	9.7
Concrete	
Clay	5
Copper	0.03
Asbestos-Cement	
Plastic	0.63
Steel	

Program Description:

Bureau of Indian Affairs - Schools, roads (direct)

Fiscal Year 1973 Funding:

$91 million

Guide Specifications:

No guide specifications

Contact:

Director, Engineering Systems Branch

Percent Design by Outside A-E: 90%

DEPARTMENT OF THE INTERIOR - 3

Program Summary

FY 1973 Construction Material Purchases

Portland Cement Concrete (000 tons)

Bituminous Concrete (000 tons)

Masonry (000 tons)
  Concrete Block
  Brick

Steel (000 tons)
  Structural (Negligible)
  Reinforcing
  Miscellaneous

Flat Glass (000 tons)

Waterproofing (MMSF = million square feet)

Insulation (MMSF)

Roofing (MMSF)

Wall Covering (MMSF)

Floor Covering (MMSF)

Wire (000 tons)
  Copper
  Aluminum
  Insulation - Plastic

Pipe (000 tons)
  Cast Iron
  Concrete
  Clay
  Copper
  Asbestos-Cement
  Plastic
  Steel

Program Description:

National Park Service - Recreational facilities (direct)

Fiscal Year 1973 Funding:

$53 million

Guide Specifications:

No guide specifications - negligible materials, as seen at left

Contact:

Associate Director, Engineering Department

Percent Design by Outside A-E: 50%

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	400
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	
Reinforcing	20
Miscellaneous	
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	
Concrete	
Clay	
Copper	
Asbestos-Cement	
Plastic	
Steel	

Program Description:

Bonneville Power Administration (direct)

Fiscal Year 1973 Funding:

$85 million

Guide Specifications:

Specifications prepared on case-by-case basis

Contact:

Director, Engineering Department

Percent Design by Outside A-E: 20%

DEPARTMENT OF THE INTERIOR - 5

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	
Reinforcing	
Miscellaneous	
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	7
Concrete	
Clay	4
Copper	
Asbestos-Cement	
Plastic	0.4
Steel	

Program Description:

Bureau of Reclamation - Small irrigation facilities loans (indirect)

Fiscal Year 1973 Funding:

Federal - $25 million

Total - $25 million

Guide Specifications:

No guide specifications

Contact:

Division of General Engineering; Chief, Construction Contracting Activities Branch

Laws:

Small Reclamation Projects Act of 1956, as amended, PL 84-984

DEPARTMENT OF THE INTERIOR - 6

Program Summary

FY 1973 Construction Material Purchases

Portland Cement Concrete (000 tons)

Bituminous Concrete (000 tons)

Masonry (000 tons)
  Concrete Block
  Brick

Steel (000 tons)
  Structural
  Reinforcing
  Miscellaneous

Flat Glass (000 tons)

(Negligible)

Waterproofing (MMSF = million square feet)

Insulation (MMSF)

Roofing (MMSF)

Wall Covering (MMSF)

Floor Covering (MMSF)

Wire (000 tons)
  Copper
  Aluminum
  Insulation - Plastic

Pipe (000 tons)
  Cast Iron
  Concrete
  Clay
  Copper
  Asbestos-Cement
  Plastic
  Steel

Program Description:

Bureau of Outdoor Recreation - Recreation facility grants (indirect)

Fiscal Year 1973 Funding:

Federal - $125 million

Total - $250 million

Guide Specifications:

No guide specifications - negligible materials

Contact:

Assistant Director, Division of State Programs

Laws:

Land and Water Conservation Fund Act of 1965, as amended, PL 88-578, Pl 90-401, PL 91-485, PL 91-308

DEPARTMENT OF THE INTERIOR - 7

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	44
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	10
Brick	5
Steel (000 tons)	
Structural	
Reinforcing	2
Miscellaneous	
Flat Glass (000 tons)	0.7
Waterproofing (MMSF = million square feet)	0.3
Insulation (MMSF)	0.3
Roofing (MMSF)	0.3
Wall Covering (MMSF)	2
Floor Covering (MMSF)	0.7
Wire (000 tons)	
Copper	0.008
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	0.12
Concrete	
Clay	
Copper	0.006
Asbestos-Cement	
Plastic	0.006
Steel	

Program Description:

Territorial Affairs - Public facilities (indirect)

Fiscal Year 1973 Funding:

Federal - $18 million

Total - $18 million

Guide Specifications:

No guide specifications

Contact:

Territorial Affairs, Staff Assistant,
Economic Development and Environmental Affairs

Laws:

DEPARTMENT OF JUSTICE - 1

Program Summary

FY 1973 Construction Material Purchases

Portland Cement Concrete (000 tons)

Bituminous Concrete (000 tons)

Masonry (000 tons)
- Concrete Block
- Brick

Steel (000 tons)
- Structural
- Reinforcing
- Miscellaneous

Flat Glass (000 tons)

(Negligible)

Waterproofing (MMSF = million square feet)

Insulation (MMSF)

Roofing (MMSF)

Wall Covering (MMSF)

Floor Covering (MMSF)

Wire (000 tons)
- Copper
- Aluminum
- Insulation - Plastic

Pipe (000 tons)
- Cast Iron
- Concrete
- Clay
- Copper
- Asbestos-Cement
- Plastic
- Steel

Program Description:

Federal Prison System (direct)

Fiscal Year 1973 Funding:

$1 million

Guide Specifications:

No guide specifications

Contact:

Director, Facilities Engineering Department

Percent Design by Outside A-E: 100%

DEPARTMENT OF JUSTICE - 2

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	22
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	5
Brick	2
Steel (000 tons)	
Structural	
Reinforcing	1
Miscellaneous	
Flat Glass (000 tons)	0.3
Waterproofing (MMSF = million square feet)	0.2
Insulation (MMSF)	0.2
Roofing (MMSF)	0.2
Wall Covering (MMSF)	1
Floor Covering (MMSF)	0.4
Wire (000 tons)	
Copper	0.004
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	0.06
Concrete	
Clay	
Copper	0.003
Asbestos-Cement	
Plastic	0.003
Steel	

Program Description:

Law Enforcement Assistance Administration (indirect)

Fiscal Year 1973 Funding:

Federal - $8 million

Total - $11 million

Guide Specifications:

No guide specifications

Contact:

Office of Criminal Justice; Associate Administrator, Office of Operations Support

Laws:

Omnibus Crime Control and Safe Streets Act of 1968, Section C, PL 90-351 as amended by the Omnibus Crime Control Act of 1970, PL 91-644, Section E

DEPARTMENT OF TRANSPORTATION - 1

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	328
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	73
Brick	38
Steel (000 tons)	
Structural	11
Reinforcing	8
Miscellaneous	
Flat Glass (000 tons)	4.3
Waterproofing (MMSF = million square feet)	2.0
Insulation (MMSF)	2.0
Roofing (MMSF)	2.0
Wall Covering (MMSF)	13
Floor Covering (MMSF)	5.4
Wire (000 tons)	
Copper	0.064
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	2.76
Concrete	
Clay	
Copper	0.143
Asbestos-Cement	
Plastic	0.123
Steel	

Program Description:

Federal Aviation Administration - Airport facilities and equipment (direct)

Fiscal Year 1973 Funding:

$241 million

Guide Specifications:

Standard Specifications for Construction Airports

Contact:

Associate Administrator for Engineering and Development, Engineering Branch

Percent Design by Outside A-E: 100%

DEPARTMENT OF TRANSPORTATION - 2

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	107
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	11
Brick	4
Steel (000 tons)	
Structural	6
Reinforcing	2
Miscellaneous	
Flat Glass (000 tons)	.7
Waterproofing (MMSF = million square feet)	1.3
Insulation (MMSF)	1.1
Roofing (MMSF)	1.2
Wall Covering (MMSF)	2
Floor Covering (MMSF)	1
Wire (000 tons)	
Copper	.218
Aluminum	.4
Insulation - Plastic	.1
Pipe (000 tons)	
Cast Iron	2.16
Concrete	
Clay	1
Copper	.009
Asbestos-Cement	
Plastic	.106
Steel	

Program Description:

Coast Guard - Shore facilities (direct)

Fiscal Year 1973 Funding:

$50 million

Guide Specifications:

Uses Navy's guide specification

Contact:

Director, Office of Engineering; Civil Engineering Branch

Percent Design by Outside A-E: 50%

DEPARTMENT OF TRANSPORTATION - 3

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	2
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	1
Reinforcing	
Miscellaneous	
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	
Concrete	
Clay	
Copper	
Asbestos-Cement	
Plastic	
Steel	

Program Description:

Federal Railroad Administration - Railway facilities (direct)

Fiscal Year 1973 Funding:

$20 million

Guide Specifications:

No guide specifications

Contact:

Director, Office of Administration; Contracts and Procurement Division

Percent Design by Outside A-E: 100%

DEPARTMENT OF TRANSPORTATION - 4

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	19,530
Bituminous Concrete (000 tons)	36,270
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	316
Reinforcing	306
Miscellaneous	205
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	28
Concrete	1,023
Clay	47
Copper	
Asbestos-Cement	
Plastic	
Steel	55

Program Description:

Federal Highway Administration - Federal-aid highway program (indirect)

Fiscal Year 1973 Funding:

Federal - $4,597 million

Total - $5,782 million

Guide Specifications:

No guide specifications - refers to industry standards

Contact:

Chief, Office of Engineering; Federal Aid Division

Laws:

Title 23 - U.S. Code-Highways; Title 23 - Code of Federal Regulations

DEPARTMENT OF TRANSPORTATION - 5

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	840
Bituminous Concrete (000 tons)	1,560
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	14
Reinforcing	13
Miscellaneous	9
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	1
Concrete	44
Clay	2
Copper	
Asbestos-Cement	
Plastic	
Steel	3

Program Description:

Federal Aviation Administration - Airport Grants (indirect)

Fiscal Year 1973 Funding:

Federal - $300 million

Total - $526 million

Guide Specifications:

Standard Specifications for the Construction of Airports - 150/5370-1A--rely heavily on established industry specifications

Contact:

Deputy Administrator, Airport Services Branch

Laws:

Airport and Airway Development Act of 1970, as amended, PL 91-258, PL 93-44

DEPARTMENT OF TRANSPORTATION - 6

Program Summary

FY 1973 Construction Material Purchases

Portland Cement Concrete (000 tons)	3,274
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	300
Brick	
Steel (000 tons)	
Structural	218
Reinforcing	73
Miscellaneous	
Flat Glass (000 tons)	12.1
Waterproofing (MMSF = million square feet)	41
Insulation (MMSF)	30
Roofing (MMSF)	41
Wall Covering (MMSF)	48
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	.3
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	2.25
Concrete	
Clay	
Copper	0.15
Asbestos-Cement	
Plastic	0.075
Steel	

Program Description:

Urban Mass Transportation Administration - Mass transit grants (indirect)

Fiscal Year 1973 Funding:

Federal - $844 million

Total - $1,688 million

Guide Specifications:

No guide specifications

Contact:

Assistant Administrator, Office of Capital Assistance Programs

Laws:

Urban Mass Transportation Act of 1964, as amended, PL 91-453 and 88-365; Federal Aid Highway Act of 1973, PL 93-87

DISTRICT OF COLUMBIA

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	90
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	18
Brick	9
Steel (000 tons)	
Structural	7
Reinforcing	5
Miscellaneous	
Flat Glass (000 tons)	.8
Waterproofing (MMSF = million square feet)	1
Insulation (MMSF)	1
Roofing (MMSF)	1
Wall Covering (MMSF)	4
Floor Covering (MMSF)	1
Wire (000 tons)	
Copper	0.008
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	.4
Concrete	
Clay	
Copper	.02
Asbestos-Cement	
Plastic	.02
Steel	

Program Description:

General construction loans (indirect)

Fiscal Year 1973 Funding:

Federal - $94 million

Total - $94 million

Guide Specifications:

No guide specifications

Contact:

Administrator, Department of General Services, Capital Improvements Unit

Laws

Congressional appropriations

ENVIRONMENTAL PROTECTION AGENCY

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	949
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	51
Reinforcing	15
Miscellaneous	
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	
Concrete	1,825
Clay	803
Copper	
Asbestos-Cement	106
Plastic	11
Steel	

Program Description:

Municipal wastewater treatment grants (indirect)

Fiscal Year 1973 Funding:

Federal - $1,600 million

Total - $2,133 million

Guide Specifications:

No material specifications; Guidelines for Design, Operations, and Maintenance of Wastewater Treatment Facilities

Contact:

Director, Water Program Operations; Municipal Wastewater Systems Division

Laws:

Federal Water Pollution Control Act, as amended, PL 92-500

GENERAL SERVICES ADMINISTRATION

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	682
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	149
Brick	71
Steel (000 tons)	
Structural	
Reinforcing	27
Miscellaneous	
Flat Glass (000 tons)	10.6
Waterproofing (MMSF = million square feet)	4.9
Insulation (MMSF)	4.9
Roofing (MMSF)	4.9
Wall Covering (MMSF)	28
Floor Covering (MMSF)	11.2
Wire (000 tons)	
Copper	0.124
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	1.86
Concrete	
Clay	
Copper	0.093
Asbestos-Cement	
Plastic	0.093
Steel	

Program Description:

Public buildings (direct)

Fiscal Year 1973 Funding:

$279 million

Guide Specifications:

Guide Specifications for Major New Construction and Extension Projects (Series 4)

Contact:

Public Guildings Service, Design and Construction Division; Chief, Design Branch

Percent Design by Outside A-E: 80%

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	102
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	23
Brick	12
Steel (000 tons)	
Structural	4
Reinforcing	2
Miscellaneous	
Flat Glass (000 tons)	1
Waterproofing (MMSF = million square feet)	.6
Insulation (MMSF)	.5
Roofing (MMSF)	.6
Wall Covering (MMSF)	4
Floor Covering (MMSF)	2
Wire (000 tons)	
Copper	.02
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	0.9
Concrete	
Clay	
Copper	0.05
Asbestos-Cement	
Plastic	0.04
Steel	

Program Description:

Research/space flight facilities (direct)

Fiscal Year 1973 Funding:

$58 million

Guide Specifications:

General guide specifications, specific projects developed on a case-by-case basis

Contact:

Director, Facilities Engineering Division

Percent Design by Outside A-E - 65%

VETERANS ADMINISTRATION

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	136
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	30
Brick	16
Steel (000 tons)	
Structural	5
Reinforcing	3
Miscellaneous	
Flat Glass (000 tons)	2
Waterproofing (MMSF = million square feet)	.8
Insulation (MMSF)	.8
Roofing (MMSF)	.8
Wall Covering (MMSF)	5
Floor Covering (MMSF)	2
Wire (000 tons)	
Copper	.03
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	1.2
Concrete	
Clay	
Copper	0.06
Asbestos-Cement	
Plastic	.05
Steel	

Program Description:

Veterans Hospitals (direct)

Fiscal Year 1973 Funding:

$83 million

Guide Specifications:

Master Construction Guide Specifications

Contact:

Director, Office of Construction, Architectural Specifications Division

Percent Design by Outside A-E: 50%

U.S. POSTAL SERVICE

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	616
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	134
Brick	64
Steel (000 tons)	
Structural	
Reinforcing	25
Miscellaneous	
Flat Glass (000 tons)	9.5
Waterproofing (MMSF = million square feet)	4.5
Insulation (MMSF)	4.5
Roofing (MMSF)	4.5
Wall Covering (MMSF)	24
Floor Covering (MMSF)	10
Wire (000 tons)	
Copper	0.112
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	1.68
Concrete	
Clay	
Copper	0.084
Asbestos-Cement	
Plastic	0.084
Steel	

Program Description:

Postal facilities (direct)

Fiscal Year 1973 Funding:

$250 million

Guide Specifications:

No material specifications; Design Criteria for the Construction of Postal Facilities

Contact:

Director, Engineering Office, Systems Engineering Design Branch

Percent Design by Outside A-E: 100%

TENNESSEE VALLEY AUTHORITY

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	2,000
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	
Brick	
Steel (000 tons)	
Structural	
Reinforcing	100
Miscellaneous	
Flat Glass (000 tons)	
Waterproofing (MMSF = million square feet)	
Insulation (MMSF)	
Roofing (MMSF)	
Wall Covering (MMSF)	
Floor Covering (MMSF)	
Wire (000 tons)	
Copper	
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	
Concrete	
Clay	
Copper	
Asbestos-Cement	
Plastic	
Steel	

Program Description:

Power generation/transmission facilities (direct)

Fiscal Year 1973 Funding:

$522 million

Guide Specifications:

Specifications developed on a case-by-case basis

Contact:

Manager, Engineering Design and Construction Branch

Percent Design by Outside A-E: 0%

ATOMIC ENERGY COMMISSION

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	408
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	91
Brick	48
Steel (000 tons)	
Structural	14
Reinforcing	10
Miscellaneous	
Flat Glass (000 tons)	5
Waterproofing (MMSF = million square feet)	2.4
Insulation (MMSF)	2.4
Roofing (MMSF)	2.4
Wall Covering (MMSF)	16
Floor Covering (MMSF)	6
Wire (000 tons)	
Copper	.08
Aluminum	
Insulation - Plastic	
Pipe (000 tons)	
Cast Iron	3.6
Concrete	
Clay	
Copper	0.18
Asbestos-Cement	
Plastic	0.16
Steel	

Program Description:

Laboratories, research (direct)

Fiscal Year 1973 Funding:

$237 million

Guide Specifications:

Specifications developed on case -by-case basis

Contact:

Assistant Director, Division of Construction and Engineering, Construction Operations Branch

Percent Design by Outside A-E: 0%

DEPARTMENT OF DEFENSE - 1

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	1,034
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	161
Brick	123
Steel (000 tons)	
Structural	36
Reinforcing	25
Miscellaneous	
Flat Glass (000 tons)	12.9
Waterproofing (MMSF = million square feet)	11.5
Insulation (MMSF)	10.9
Roofing (MMSF)	9.2
Wall Covering (MMSF)	48
Floor Covering (MMSF)	17.2
Wire (000 tons)	
Copper	.722
Aluminum	1.2
Insulation - Plastic	.4
Pipe (000 tons)	
Cast Iron	15.24
Concrete	
Clay	6
Copper	.215
Asbestos-Cement	
Plastic	0.88
Steel	

Program Description:

Army - Military Construction (direct)

Fiscal Year 1973 Funding:

$556 million

Guide Specifications:

Guide Specifications for Military Construction

Contact:

Office of the Chief of Engineers, Military Construction Directorate

Percent Design by Outside A-E - 80%

DEPARTMENT OF DEFENSE - 2

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	709
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	95
Brick	40
Steel (000 tons)	
Structural	35
Reinforcing	16
Miscellaneous	
Flat Glass (000 tons)	5.3
Waterproofing (MMSF = million square feet)	8.6
Insulation (MMSF)	7.6
Roofing (MMSF)	8.1
Wall Covering (MMSF)	21
Floor Covering (MMSF)	5
Wire (000 tons)	
Copper	.592
Aluminum	1.2
Insulation - Plastic	0.4
Pipe (000 tons)	
Cast Iron	11.0
Concrete	
Clay	5
Copper	0.10
Asbestos-Cement	
Plastic	0.686
Steel	

Program Description:

Navy - Military Construction (direct)

Fiscal Year 1973 Funding:

$306 million

Guide Specifications:

Guide Specifications for Use in Regular Military Construction Projects

Contact:

Naval Material Command; Naval Facilities Engineering Command, Engineering and Design Branch

Percent Design by Outside A-E: 75%

DEPARTMENT OF DEFENSE - 3

Program Summary

FY 1973 Construction Material Purchases	
Portland Cement Concrete (000 tons)	693
Bituminous Concrete (000 tons)	
Masonry (000 tons)	
Concrete Block	107
Brick	52
Steel (000 tons)	
Structural	28
Reinforcing	19
Miscellaneous	
Flat Glass (000 tons)	6.5
Waterproofing (MMSF = million square feet)	8.4
Insulation (MMSF)	7.2
Roofing (MMSF)	7.9
Wall Covering (MMSF)	23
Floor Covering (MMSF)	6.8
Wire (000 tons)	
Copper	0.3
Aluminum	0.4
Insulation - Plastic	0.1
Pipe (000 tons)	
Cast Iron	4.21
Concrete	
Clay	1
Copper	.109
Asbestos-Cement	
Plastic	0.198
Steel	

Program Description:

Air Force - Military Construction (direct)

Fiscal Year 1973 Funding:

$277 million

Guide Specifications:

Use Army/Navy guide specifications

Contact:

Deputy Chief of Staff, Programs and Resources;
Director of Civil Engineering, Engineering
Division

Percent Design by Outside A-E: 50%

APPENDIX B

NAVAL FACILITIES ENGINEERING COMMAND GUIDE SPECIFICATIONS FOR USE IN REGULAR MILITARY CONSTRUCTION PROJECTS

Source: Construction Specifications Institute, Master Index of Government Guide Specifications for Construction, 2nd Edition.

DEPARTMENT OF THE NAVY, NAVAL FACILITIES ENGINEERING COMMAND (NAVFAC)

TYPE (GUIDE) SPECIFICATIONS FOR USE IN REGULAR MILITARY CONSTRUCTION PROJECTS

DIVISION 1: GENERAL REQUIREMENTS

TS-M129W	Sep 70	Format and General Paragraphs for the Preparation of Manuscripts of Specifications for Construction Contracts for Public Works
TS-P62a	Feb 64	Pert/time Management Information System

DIVISION 2: SITE WORK

TS-B1e	Mar 66	Soil Boring and Sampling
TS-2D3	Aug 71	Dredging
TS-D4d	Mar 66	Duct for Cable Under Existing Airfield Pavement
TS-2E1a	Aug 71	Earthwork
TS-2F16	Jun 71	Pressure Injected Footings
TS-J2c	Feb 63	Resealing of Joints in Rigid Pavement at Airports
TS-P2d	Jul 63	Composite Wood and Concrete Piling
TS-02310	Feb 72	Round Timber Piles
TS-2P12	Aug 69	Bonded Concrete Overlay Pavement
TS-P13c	Dec 62	Select Material Base Course for Rigid Pavement
TS-P14e	Dec 62	Select Material Subbase Course for Flexible Pavement
TS-2P16	Jun 71	Bituminous Base Course (Central Plant Hot Mix)
TS-2P18	Jun 68	Graded Aggregate Base Course for Flexible Pavements
TS-2P21g	Jun 67	Bituminous Tack Coat
TS-P22g	Nov 66	Bituminous Prime Coat
TS-2P23a	Aug 68	Asphalt Binder and Wearing Courses for Flexible Pavement (Central Plant Hot Mix)
TS-2P24	Sep 67	Bituminous Seal Coat
TS-2P25	Sep 67	Single Bituminous Surface Treatment
TS-2P26a	Oct 71	Double Bituminous Surface Treatment
TS-P47a	Jun 64	Paving of Water Catchment Areas
TS-2P57	Jun 71	Prestressed Concrete Piling
TS-P63	Jan 64	Planing Asphalt Pavement
TS-2P67	Jul 71	Steel H-Bearing Piles

TS-2P69a	Mar 71	Auger-Placed Concrete Piles
TS-2P71	Jun 67	Fog Seal
TS-2S2	Mar 68 Jun 71	Exterior Sanitary Sewer and Drainage Systems Change No. 1
TS-2S3	Jul 68	Asphalt Slurry Seal
TS-S7	Mar 64	Coal-Tar Slurry Seal
TS-T18a	Jul 65	Timber Harvesting
TS-T19b	Nov 67	Timber Stand Improvement
TS-2W8	Oct 69 Jun 71	Water Distribution System Change No. 1
TS-02110	Sep 72	Demolition
TS-02240	Oct 72	Environment Protection
TS-02250	Dec 72	Soil Treatment
TS-02317	Nov 72	Cast-in Place Concrete Piles, Steel Casing
TS-02711	Sep 72	Fence, Chain Link
TS-02910	Nov 72	Welding Crane Rails-Thermite "Self-Preheat Method"

DIVISION 3: CONCRETE

TS-C2c	Apr 63	Precast Structural Concrete
TS-R9	Apr 65	Cast-in-place Gypsum Roof Decks
TS-03300	Nov 72	Cast-in-place Concrete

DIVISION 4: MASONRY

TS-M1e	Aug 66 Feb 71	Brick, Hollow Tile, and Concrete Masonry Unit Work Change No. 1
TS-T13a	Jun 66	Ceramic Glazed Structural Clay Facing Tile and Prefaced Concrete Masonry Unit

DIVISION 5: METALS

TS-F18	Jul 65 Jul 71	Steel Sub-floors (Cellular and Non-cellular) Steel Floor Decks (Cellular) Change No. 1
TS-5R10	Dec 67 Mar 71	Steel Roof Decks Change No. 1
TS-S8	Apr 65	Open Web Steel Joists
TS-05120	Jul 72	Structural Steel

DIVISION 6: WOOD AND PLASTICS

TS-6C18	Feb 69	Framing and Rough Carpentry
	Jul 69	Change No. 1
	Jan 71	Change No. 2
TS-6C19	Feb 69	Exterior and Interior Finish Carpentry
	Jan 71	Change No. 1

DIVISION 7: THERMAL AND MOISTURE PROTECTION

TS-R6	Oct 64	Corrugated Metal Roofing and Siding
TS-R7	Oct 64	Corrugated Cement-Asbestos Roofing and Siding
TS-R8	May 65	Elastomeric Roofing Systems
	Jan 71	Change No. 1
TS-07160	Sep 72	Bituminous Dampproofing
TS-07140	Sep 72	Metallic Oxide Waterproofing
TS-07210	Jul 72	Perimeter Insulation
TS-07221	Jul 72	Cavity Wall Insulation
TS-07232	Jul 72	Ceiling, Wall and Crawl Space Insulation
TS-07241	Jul 72	Roof Insulation
TS-07310	Jul 72	Asphalt Shingles
TS-07600	Jul 72	Flashing and Sheet Metal
TS-07510	Jul 72	Built-up Bituminous Roofing
TS-07951	Nov 72	Calking and Sealants

DIVISION 8: DOORS AND WINDOWS

TS-8D9	Mar 71	Sliding Hangar Doors
TS-8D10	Feb 69	Wood Doors and Windows
TS-8H15	Apr 69	Builders' (Finish) Hardware
	Feb 71	Change No. 1
	Jul 71	Change No. 2
TS-8H16	Apr 69	Specification for Selecting Builders' Hardware *
TS-8H17	Apr 69	List of Builders' Hardware Samples on File in Washington, D. C.
TS-08110	Nov 72	Hollow Metal Doors and Frames
TS-08120	Sep 72	Aluminum Doors and Frames
TS-08310	Sep 72	Fire Doors

TS-08320	Oct 72	Metal-Clad (Kalamein) Doors and Frames
TS-08330	Sep 72	Accordian and Ceiling Steel Service Doors
TS-08360	Oct 72	Overhead and Vertical Lift Steel Doors
TS-08371	Sep 72	Aluminum Sliding Glass Doors
TS-08510	Jul 72	Steel Windows
TS-08520	Sep 72	Aluminum Windows
TS-08810	Sep 72	Glass and Glazing
TS-08900	Sep 72	Curtain Wall Systems

DIVISION 9: FINISHES

TS-9F15a	Apr 71	Metallic-type Static-disseminating and Spark-resistant Floor Finish (for Ordnance and Other Structures)
	May 71	Change No. 1,
TS-9F22	Jun 70	Wood Strip Floor Systems
	May 71	Change No. 1
TS-9F23a	May 71	Wood Parquet Floor Systems
TS-9F24a	May 71	Wood Block (End Grain) Industrial Flooring
TS-9P9	Oct 70	Plastering and Stuccoing
	Feb 71	Change No. 1
TS-9P30	Mar 71	Protection of Buried Steel Piping and Steel Bulkhead Tie Rods
TS-9P74	Feb 70	Painting of Drydock AMMI Pontoon
TS-9P75	Feb 70	Painting of Fuel Storage AMMI Pontoon
TS-9P76	Feb 70	Painting of General Purpose AMMI Pontoon
TS-9P77	Feb 70	Painting of Mobile Facility AMMI Pontoon
TS-9P78	Feb 70	Painting of Water Storage AMMI Pontoon
TS-9T3	Oct 70	Tile Work
	Feb 71	Change No. 1
TS-T21	Mar 63	Acid-resisting Quarry Tile Floor
	Jan 71	Change No. 1
TS-W9	Mar 66	Gypsum Wallboard
TS-09110	Dec 72	Metal Studding, Metal Furring and Metal and Gypsum Lathing
TS-09411	Sep 72	Terrazzo, Bonded to Concrete
TS-09500	Nov 72	Acoustical Treatment
TS-09650	Sep 72	Resilient Flooring

TS-09910	Jul 72	Painting of Buildings (Field Painting)
TS-09951	Oct 72	Vinyl Coated Wall Covering

DIVISION 10: SPECIALTIES

TS-MP1	Jul 60	Movable Partitions
TS-10P32	Dec 67	Metal Toilet Partitions
TS-P65	May 64	Folding Fabric Partitions
TS-10T24a	May 71	Metal Toilet and Bath Accessories

DIVISION 11: EQUIPMENT

TS-11400	Dec 72	Food Service Equipment
TS-11874	Sep 72	Adjustable Loading Ramp (Power Operated)

DIVISION 12: FURNISHINGS

TS-12322	Dec 72	Wardrobes
TS-D6a	Mar 66	Drapery Rods
	Jan 71	Change No. 1
	Apr 71	Change No. 2
TS-12321	Dec 72	Wardrobes Storage Cabinents 3-Drawer

DIVISION 13: SPECIAL CONSTRUCTION

TS-B2	Mar 66	Prefabricated Metal Buildings (Straight Walls)
TS-13B3	Sep 68	Relocatable Structures (Procurement for Use)
	Apr 71	Change No. 1
TS-13F12	Aug 71	Raised Floor System (for Data Processing Equipment Rooms)
TS-13F25	Jun 70	Portable (Demountable) Wood Floor Systems
	May 71	Change No. 1

DIVISION 14: CONVEYING SYSTEMS

TS-W6	Apr 63	Welding Crane Rails
	Jul 63	Change No. 1

DIVISION 15: MECHANICAL

TS-F2b	Mar 61	Diatomaceous Earth Type Filtration and Purification Equipment for Swimming Pools
TS-F4a	Apr 66	Sprinkler System, Automatic, Dry Pipe Type
	Jun 71	Change No. 1

TS-F5a	Apr 66	Sprinkler System, Automatic, Deluge Type
TS-F6a	Apr 66	Sprinkler System, Automatic, Wet Pipe Type
TS-F10	Dec 62	Aviation Fuel Distribution System
TS-H1b thru TS-H11b	Jan 62	Heating Plants, Consolidated Specifications for Steam and HTW Systems
TS-15 H7	Apr 69	Heating Plant No. 7, 8,000,000 to 36,000,000 Btu/hour, Coal, Oil or Gas Fired, Natural Steam Pressurized HTW System
	Jun 71	Change No. 1
TS-15H8	Apr 69	Heating Plant No. 8, 20,000,000 to 120,000,000 Btu/hour, Coal, Oil, or Gas Fired Natural Steam Pressurized HTW System
TS-15H9	Apr 69	Heating Plant No. 9, 50,000 to 120,000,000 Btu/hour, Coal, Oil, or Gas Fired, Nitrogen Pressurized HTW System
	Jun 71	Change No. 1
TS-15H10	Apr 69	Heating Plant No. 10, 100,000,000 to 210,000,000 Btu/hour, Coal, Oil, or Gas Fired, Nitrogen Pressurized HTW System
	Jun 71	Change No. 1
TS-L2b	Apr 63	Water Level and Draft Indicating System (Pneumatic Type)
TS-L3	Apr 63	Water Level and Draft Indicating System (Electro Pneumatic Type)
TS-15P28	May 69	Heat Distribution Systems Outside of Buildings
	Jan 71	Navy CQC Supplement No. 1
TS-P35a	Jul 59	Power Plant, Steam-electric Generating, 5,000 kw, Straight Condensing Oil Fired **
TS-P36a	Jul 59	Power Plant, Steam-electric Generating, 5,000 kw, Automatic Extraction Oil Fired **
TS-P37a	Jun 60	Power Plants, Steam-electric Generating, 10,000 kw, Straight Condensing, Oil Fired **
TS-P40a	Jul 59	Power Plant, Steam-electric Generating, 15,000 kw, Automatic Extraction Oil Fired **
TS-P41a	Jun 60	Power Plant, Steam-electric 23,500 kw, Straight Condensing Oil Fired **
TS-P42a	Jun 60	Power Plant, Steam-electric Generating, 20,000 kw, Automatic Extraction, Oil Fired **
TS-P43a	Jun 60	Power Plants, Steam-electric Generating, 5,000 kw, Automatic Extraction, Coal-Oil Fired **
TS-P45a	Jul 59	Power Plants, Steam-electric Generating, 15,000 kw, Automatic Extraction, Coal-Oil Fired **
	Aug 71	Change No. 1
TS-P49a	Aug 65	Power Plants, Diesel-electric Generating, Design 1, Continuous Duty, 201 to 500 kw, Units **
	Aug 71	Change No. 1
TS-P50a	Aug 65	Power Plants, Diesel-electric Generating, Design 2, Continuous Duty, 501 to 1000 kw, Units **
TS-P51a	Aug 65	Power Plants, Diesel-electric Generating, Design 3, Continuous Duty, 1001 to 1500 kw, Units **

TS-P52a	Aug 65	Power Plants, Diesel-electric Generating, Design 4, Continuous Duty 1501 to 3500 kw, Units **
	Aug 71	Change No. 1
TS-P53a	Sep 65	Power Plants, Diesel-electric Generating, Design 5, Standby Duty 101 to 700 kw, Units **
	Aug 71	Change No. 1
TS-P54a	Sep 65	Power Plants, Diesel-electric Generating, Design 6, Standby Duty 701 to 1250 kw, Units **
TS-P55a	Aug 65	Power Plants, Diesel-electric Generating, Emergency Duty, 201 to 600 kw, Units **
TS-P59	Nov 62	Plumbing Systems, Interior
TS-P60	Mar 63	Piping, Gas, Interior
TS-P61	Mar 63	Piping, Oil, Interior
TS-S9	Mar 67	Prefabricated Sewage-treatment Plant
TS-S11	Mar 67	Prefabricated Sewage Lift Station
TS-15S15	Jul 71	Circular Clarifier
	Sep 71	Change No. 1
TS-15S18	Jul 71	Trickling Filter
TS-15S19	Nov 70	Comminutor
TS-15T6	Sep 68	Steel Tanks with Floating Roofs
	May 71	Change No. 1
TS-15T8	Sep 68	Steel Tanks with Fixed Roofs
	Mar 71	Change No. 1
TS-15T10	Oct 68	Underground Vertical Steel Tanks
TS-15T22a	Jun 68	Steel Tanks with Covered Floating Roofs
	Mar 71	Change No. 1
TS-15057	Sep 72	Coal Tar Coating Systems for Steel Structures
TS-15180	Feb 73	Insulation of Mechanical Systems
TS-15384	May 72	Rectangular Clarifier
TS-15390	May 72	Aeration Equipment
TS-15393	May 72	Flow Measuring Equipment
TS-15406	Oct 72	Oxide Piping Systems
TS-15408	Oct 72	Nitrous Oxide Piping Systems
TS-15409	Oct 72	Vacuum Piping System
TS-15552	Jun 72	Central Refrigeration Equipment for Air Conditioning
TS-15602	Nov 72	Air Supply Systems

DIVISION 16: ELECTRICAL

TS-16A9a	Mar 68 May 71	Airfield Lighting Change No. 1
TS-16C22	Dec 69 Jul 71	Electronic Intercommunication System Change No. 1
TS-16F1	Jan 68 Jan 71	Fire Alarm System (Shunt, Non-interfering Type) Change No. 1
TS-16F19	Sep 67 Jan 68	Radio Frequency Filters for 60 Cycle Power Lines Change No. 1
TS-16F21	Jan 68 Jan 71	Fire Alarm System (Positive, Non-interfering Type) Change No. 1
TS-16L4	Sep 67 Mar 71	Outdoor Lighting Change No. 1
TS-16R11	Sep 70	Receptacles and Plugs, Electrical (for Aircraft Ground Support Equipment)
TS-16113	Sep 72	Underfloor Duct Systems
TS-16300	May 72	Electrical Distribution, Exterior
TS-16335	Apr 72	Transformers, Substation and Switchgear, Exterior
TS-16402	Jul 72	Interior Wiring Systems
TS-16475	Apr 72	Transformers, Substations and Switchgear, Interior
TS-16570	Sep 72	Watchman's Clock System
TS-16761	Sep 72	Intercommunication System
TS-16852		Electrical Space Heating Equipment

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* Available only from NAVFAC HQ

** A limited supply was printed. Copies should only be requested when a particular need for the specification exists.

APPENDIX C

DESCRIPTIONS OF CONSTRUCTION PRODUCTS MADE FROM WASTE GLASS

Product: Terrazzo Floors

Description: Glass chips sorted and blended by color and size set into a matrix of portland cement or a "Poly-Mod" mixture of cement and a polymer. Floor is polished to show glass aggregate.

Status of Development: Two floors have been used successfully for almost four years at Emhart in Windsor, Ct., and the Fullerton Air Industrial Park, Fullerton, Ca. Basic research was conducted by the Bureau of Mines at Tuscaloosa, Ala.

Unique Advantages: Harder than marble. Can easily compete with marble's high cost of $30-$120 per ton.

Constraints: Glass must be source separated to achieve quality, size and color balance.

*Plant Investment: Low

Quality of Glass Required: Large chips, clean and color separated.

**Economics: Value - $30-$100+/ton
Recovery Cost - Source Separation

Market: Traditional terrazzo floor market. If 100 percent of the marble could be replaced by glass, that would amount to .8 million tons nationally in 1974. Market is growing at 7 percent per year.

Contact: Pickett Scott, Glass Containers Corp., 535 North Gilbert Avenue, Fullerton, California 92634.

Reports: The Commercial Potential of Terrazzo with Wash Glass Aggregate, Midwest Research Institute. Published by GCMI, 1800 K Street, N.W., Washington, D.C. 20006.

Symposium on Utilization of Waste Glass in Secondary Fibers, University of New Mexico, Glass Container Manufacturers Institute (GCMI), Albuquerque, New Mexico. One paper of special interest is "Terrazzo and Other Glass Products in Existing Buildings" by Pickett Scott of Glass Containers Corporation, Fullerton, California.

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*Low - $0-$150,000
Medium - $150,000-$500,000
High - $500,000 and above

These figures represent incremental investment in these cases where existing plant can be utilized.

**Value of glass in product.

Cost to separate glass in resource recovery system, if applicable.

Figures are approximate.

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Product: Thixite®

Description: A strong durable tile or panel made with various mixtures of ground glass, clay, construction rubble and glass chips. The product is vibratory casted and fired to the size and shape desired in virtually any size and shape desired. Decorative effects can be achieved with different aggregate and surface treatments.

Status of Development: 4,000 SF are incorporated into the picnic pavilion in Washington Park, Denver.

Unique Advantages: Uses 94 percent waste materials. Saves over 400°F in firing temperature vs. bricks. Can command high price for glass.

Constraints: New material--will face market development period.

Plant Investment: Low

Quality of Glass Required: Basic mixture can accept glass-rich separation plant output if it is free of organics. Glass chips must be large and color sorted when used for visual effect.

Economics: Value - $30-$100+ton
Recovery Cost - $2-$5/ton

Market: The market for architectural wall board is about 961 million square feet in 1974 and is growing at about 7 1/4 percent annually. Thixite containing 31 percent waste glass could theoretically consume 1.4 million tons in 1974.

Contact: Patent Licensee-Thixon Corporation, 1367 Harlan Street, Lakewood, Colorado 80214. Patent Holder-GCMI, 1800 K Street, N.W., Washington, D. C. 20006.

Reports: The Commercial Potential of Glass-Rubble Building Panels, Midwest Research Institute, Published by BCMI, 1800 K Street, N.W., Washington, D. C. 20006.

Product: Pozzolan

Description: Waste glass is ground to minus 100 mesh and used as a concrete additive to counteract reactions between cement and certain siliceous aggregates.

Status of Development: Experiments have been successfully conducted at the Colorado School of Mines.

Unique Advantages: Glass has a more consistent chemical composition than pozzolans in use today.

Constraints: Would replace materials which are themselves recovered wastes.

Plant Investment: Low

Quality of Glass Required: Lightly contaminated--mixed colors.

Economics: Value - $16-$21/ton
Recovery Cost - $4-$6/ton

Market: Total annual tonnage rose dramatically to about 800,000 tons. Heaviest use in the Midwest.

Contact: Maurice Pattengill. Colorado School of Mines Research Institute, P. O. Box 112, Golden, Colorado.

Reports: Symposium on Utilization of Waste Glass in Secondary Products, January 24-25, Albuquerque, New Mexico. Sponsored by the Technology Application Center, University of New Mexico, The Glass Container Manufacturers Institute, the Albuquerque Dept. of Environmental Health. One paper of particular interest is "Use of Ground Glass as a Pozzolan" by Maurice Pattengill and T. C. Shutt of Colorado School of Mines Research Institute.

Product: Foamed Glass Panels

Description: Waste glass foamed with a variety of foaming agents to produce a line of wallboard, sandwich wall cores, acoustic panels, glazed panels, roofing materials, etc. Products have good sound and heat insulating characteristics and can be made with a variety of decorative effects. One licensee of the UCLA patents calls their product Envirite^{tm}.

Status of Development: Process has been perfected at both UCLA and University of Utah. Several applications of Envirite are in use in the Fullerton Air Industrial Park, Fullerton, Cal.

Unique Advantages: New construction product having many attractive features which should allow it to compete with a broad spectrum of traditional materials.

Constraints: New Material--will face market development period.

Plant Investment: Medium

Quality of Glass Required: Can be quite dirty. Organics will burn off during processing.

Economics: Value - $3-$16/ton
Recovery Cost - $1-$3/ton

Market: Envirite will probably compete best in the insulating wallboard market which is about 3,800 million square feet in 1974. This translates to about 1.5 million tons per year of waste glass.

Contact: Dr. J. Douglas MacKensie, University of California, Los Angeles, School of Engineering, Boelter Hall, Room 6532, Los Angeles, Cal. 90024; Mr. Jerry D. Johnson, Environ Control Products, Inc., 16128 Leadwell Street, Van Nuys, Cal. 91406; B. D. Mardrant and I. B. Cutler, Division of Materials Science and Engineering, University of Utah, Salt Lake City, Utah.

Reports: The Commercial Potential of Foamed Glass Construction Materials made with Waste Glass and Animal Excreta, Midwest Research Institute. Published by GCMI, 1800 K Street, N. W., Washington, D. C. 20006.

Symposium on Utilization of Waste Glass in Secondary Products, sponsored by the Technology Application Center, University of New Mexico, GCMI, Inc.

Product: Ceramic Bricks

Description: Ceramic bricks are traditional red bricks which are predominantly used as facing bricks all across the country. The U.S. Bureau of Mines has run some successful tests on the use of ground glass as a replacement for clay in bricks. They have found that the strength holds up very well, and have also discovered an important advantage in using glass in the makeup of a brick body (i.e., there are great energy savings when the bricks are fired which are proportional to the amounts of glass used). Not only is energy saved but also the residence time in the kilns is drastically reduced. For brick manufacturers who are facing capacity constraints, this reduction of kiln time is an important advantage. The presence of the glass makes little or no change in the appearance of the bricks and of course the bricks would continue to be sold by the existing distribution networks.

Glass from resource recovery plants will probably be acceptable with the only exception being that all aluminum must first be extracted.

Status of Development: Good quality bricks have been produced by the Bureau of Mines and brick makers in California. The National Center for Resource Recovery plans to do further testing in cooperation with a brick maker on the East Coast.

Unique Advantages: No new product distribution effort required. Large energy savings in manufacturing.

Plant Investment: Low.

Quality of Glass Required: Can be contaminated but all aluminum should be removed.

Economics: Value \$2-\$12/ton
Recovery Cost - \$2-\$4/ton

Market: Assuming a clay replacement of 35 percent, the annual U.S. market would be about 7.1 million tons.

Contact: M. E. Tyrrell and I. L. Feld, Tuscaloosa Metallurgy Research Lab, Tuscaloosa, Alabama; J. A. Barclay, College Metallurgy Research Center, College Park, Maryland.

Reports: USBM, Fabrication and Cost Evaluation of Experimental Building Brick from Waste Glass, R.I. 7605 by M. E. Tyrrell and I. L. Feld, Tuscaloosa Metallurgy Research Lab, Tuscaloosa, Alabama.

USBM, Economic Studies of Uses of the Glass Fractions from Municipal Incinerator Residues, R.I. 8567 by Paul W. Johnson and James A. Barclay, College Park Metallurgy Research Center, College Park, Maryland.

USBM, Glass Wool from Waste Glass, R.I. 7708, by Alan H. Goode, M.E. Tyrell and I. L. Feld, Tuscaloosa Metallurgy Research Lab, Tuscaloosa, Alabama.

Product: Glass-Excreta Tiles

Description: Aside from the study for foamed glass panels, UCLA has also developed a strong light-weight tile which is made in a like manner. However, the excreta is not volitalized as the tiles are fired under pressure. Instead, the excreta particles remain intact while the glass fuses and forms a strong matrix around the light particles. Except for their lightness, these tiles are not significantly different from products currently on the market. They would probably be manufactured at the same plant as the foamed glass panels, and would be able to accept as input the same quality of glass (i.e., somewhat contaminated) coming from resource recovery plants.

Status of Development: Processes have been perfected at UCLA.

Unique Advantages: The most attractive features of this product is its being lightweight, fire proof and attractive in appearance.

Plant Investment: Medium

Quality of Glass: Can be dirty as organics will burn off during processing.

Economics: Value - $2-$11/ton
Recovery Costs - $1-$3/ton

Market: The market for glass excreta tiles is roughly 300,000 tons per year.

Contacts: Dr. MacKenzie and Jerry D. Johnson, Environ Control Products, Inc., 16128 Leadwell Street, Van Nuys, California 91406, (213) 994-2392.

Reports: The Commercial Potential of Ceramic Tiles Made with Waste Glass and Animal Excreta, Midwest Research Institute, published by GCMI, Inc., 1800 K Street, N.W., Washington, D. C. 20006.

Product: Foamed Light-Weight Aggregate

Description: Light-weight aggregate has become an important cost saving ingredient in concrete structures. The U. S. Bureau of Mines in Tuscaloosa, Alabama has developed a process to convert finely ground waste glass into a foamed light-weight aggregate. The process could utilize rotary kilns which are presently owned by manufacturers of traditional light-weight aggregate which is made by heating certain types of shale until they bloat. The USBM found it could achieve high quality aggregate by foaming the glass and thereby offer at least two significant advantages: 1) in many sections of the country the freight on the raw material would be drastically reduced and 2) there will be a great energy savings because glass melts (foams) at a lower blasting temperature than the shale.

Status of Development: Experimental. Based on studies done by USBM, Metallurgy Lab, Tuscaloosa, Alabama.

Unique Advantages: Energy savings in manufacture and freight savings for raw materials (for many sections of the country). Also existing distribution channels can be utilized.

Plant Investment: Low

Quality of Glass Required: Somewhat contaminated - more experimental work needed.

Economics: Value $3-$6/ton
Recovery Costs - $1-$3/ton

Market: Large and growing. Could potentially accept 5.7 million tons of waste glass per year.

Contact: Miles Tyrrell or Martin H. Stanczyk, Tuscaloosa Metallurgy Research Lab, Tuscaloosa, Ala.

Reports: None published yet.

Product: Glass Wool Insulation

Description: Glass wool is a well-known insulating product made of finely drawn glass fibers. Early experimental and even some commercial operation has shown that a good grade of glass wool can be produced from waste glass. One major manufacturer feels that a great deal more pilot plant work needs to be done so that potential contaminants in garbage or in the waste glass itself can be controlled.

Status of Development: Some problems remain to be solved before large scale operation can commence. Presently, Sealite Corporation is producing glass wool from waste glass.

Unique Advantages: Energy savings. Can use existing channels of distribution.

Constraints: Chemicals present in garbage and waste glass may delay technology.

Plant Investment: High

Quality of Glass Required: Clean but not color separated.

Economics: Value - $3-$6/ton
Recovery Costs - $4-$6/ton

Market: Small in relation to the total of waste glass available. Only about 500,000 tons per year but growing rapidly because of the energy crisis.

Contact: Walter Gubar, Director, Research Lab, Certain-Teed Saint Gobain Insulation Corporation, P. O. Box 15080, Kansas City, Mo. 66115; Mr. Miles Firnhaber, Sealite Corporation, P. O. Box 344, Waukesha, Wisconsin 53186.

Reports: USBM, Glass Wool from Waste Glass, R. I. 7708, by Alan H. Goode, M. E. Tyrell, and I. L. Feld, Tuscaloosa Metallurgy Research Lab, Tuscaloosa, Ala.

The Commercial Potential of Glass Wool Insulation, by Midwest Research Institute, published by GCMI, 1800 K Street, N. W., Washington, D. C. 20006.

Product: Glass-Polymer Concrete

Description: Glass-polymer concrete is produced by mixing crushed waste glass with monomer, either methyl methacrylate or polyester stryene and polymerizing by chemical initial techniques. The amount of monomer loadings can be as low as 9-10 percent. The strength of this concrete is 2 to 4 times as high as ordinary concrete. One major advantage is the resistance to chemical attack. Therefore, the most logical application has been for sewer pipes and pipes for more corrosive industrial liquids. The same process can be applied with other aggregate materials, including common crushed stone.

Status of Development: Several types of pipe and other materials have been fabricated. On October 30, 1972 a 30 foot section of glass polymer concrete sewer pipe was installed in Huntington, Long Island, New York.

Unique Advantages: Resistance to corrosion.

Constraints: The glass would be used as a substitute aggregate for other more common aggregates and therefore can command only a low value. The only exception is for high corrosion uses, which is a small market.

Plant Investment: Low

Quality of Glass Required: Glass can be quite dirty.

Economics: Value - $2-$5/ton
Recovery Costs - $2-$4/ton

Market: If GPC could capture the entire 8 inch to 24 inch sewer pipe market, it could use 2.7 million tons of glass per year.

Contact: Morris Beller and Meyer Steinberg, Department of Applied Science, Brookhaven National Lab, Upton, New York.

Reports: Symposium on Utilization of Waste Glass in Secondary Products sponsored by Technology Application Center, University of New Mexico, the Glass Containers Manufacturers Institute, Inc., Jan. 24-25, 1973, Albuquerque, New Mexico.

M. Beller and M. Steinberg, Glass-Polymer Composites, Brookhaven National Lab, Upton, New York.

A. D. Little, Glass Polymer Conposite Sewer Pipe - An Initial Evaluation of its Commercial Potential, prepared by R. S. Lindstrom and Dr. Jack Milgrom.

Product: Glasphalt

Description: The use of waste glass as an aggregate in an asphaltic mixture is called glasphalt. It is one of the earliest products to emerge as a secondary use of waste glass. Laboratory studies began in 1969 at the University of Missouri. For the 30 or more test strips of glasphalt in use around the country, results have been satisfactory except for a very few cases. Tests run by the U.S. Federal Highway Administration indicate a potential problem with "stripping," or poor adherence of liquid asphalt to the glass particles. The potential market is over 150,000,000 tons of waste glass per year, significantly in excess of the 12 million tons of glass in the solid waste stream. Glasphalt enables paving contractors to pave several weeks later in the fall and to begin paving several weeks earlier in the spring because it takes longer to cool than conventional asphalt. Another feature is that glasphalt can accept a high percentage of nonglass materials (up to 17 percent in some tests).

Because of the low value of the glass as a substitute for crushed rock, it may be hard to generate much interest in developing and promoting the product by industry.

Status of Development: Many test strips across the country.

Unique Advantages: Cold weather paving and ability to take very contaminated glass.

Constraints: Low value will not stimulate product demand.

Plant Investment: Low

Quality of Glass Required: Can be very dirty.

Economics: Value - $2-$5/ton
Recovery Cost - $1-$3/ton

Market: If glass could replace 50 percent of all black-top paving aggregate, this would represent a market of 150 million tons per year.

Contact: Ward R. Malisch and Delbert E. Day, Engineering Research Lab, University of Missouri, Rolla, Missour.

Reports: Papers presented at Symposium on Utilization of Waste Glass in Secondary Products, sponsored by Technology Application Center, University of New Mexico, GCMI, Inc., Albuquerque, New Mexico, January 24, 25, 1973.

Ward R. Malisch, James J. Schneider, Bobby G. Wixson, University of Missouri, Laboratory and Field Experience with Asphaltic Concretes Containing Glass Aggregates.

John P. Cummings, Owens-Illinois Co., Waste Glass in Road Construction.

Product: Slurry Seal

Description: Slurry seal is a specially prepared and cured surface for roads. The seals provide protection against moisture penetration, and wear and tear from traffic and protection against skidding. It has been demonstrated on several strips that slurry seal containing large portions of glass as an aggregate is better than, or at least equal to conventional slurry seal. There is evidence to show that slurry seal with glass provides resistance against skidding because as the traffic wears down the matrix, the small particles of glass will break off and expose new angular glass surfaces. Neither heat nor solids are required in the preparation of slurry seal.

Status of Development: Successfully demonstrated in several strips, including Waco, Texas and New Orleans, Louisiana.

Unique Advantages: Increased skid resistance.

Constraints: Low value for glass when substituted for conventional rock aggregates.

Plant Investment: Low

Quality of Glass Required: Can be quite contaminated.

Economics: Value - $2-$5/ton
Recovery Cost - $2-$4/ton

Market: The total aggregate could be substituted with glass and would amount to 1.4 million tons in the United States annually.

Contact: R. T. Young of Slurry Seal Inc., Waco, Texas.

Reports: "Commercial Potential of Slurry Seal with Waste Glass Aggregate," by Midwest Research sponsored by GCMI, 1800 K Street, N.W., Washington, D.C.

The American City Magazine, "Slurry Seal Program - A Political Asset," Buttenheim Publishing Co., March 1972.

Product: Glass-Portland Cement Concrete

Description: Glass has been used as a replacement for sand and some of the smaller crushed rock aggregates in concrete. It has been demonstrated in the Air Industrial Park in Fullerton, California. Some of the basic research was conducted at the Thayer School of Engineering at Dartmouth, Hanover, New Hampshire. The results of strength tests have been somewhat mixed, but it is concluded that glass can be used in nonstructural concrete especially where the decorative effect of glass chips can be used advantageously. Generally, however, the use of glass in concrete is little better than a disposal strategy because the competing aggregates are quite inexpensive.

Status of Development: Demonstrated in the Fullerton Air Industrial Park, basic research at Thayer School at Dartmouth College.

Unique Advantages: Can be used for interesting decorative effects.

Constraints: May develop strength problems in structural concrete.

Plant Investment: Low

Quality of Glass: Glass must be free of organics.

Economics: Value - \$2-\$5/ton
Recovery Cost - \$2-\$6/ton

Market: The potential markets are very large. Considering the use of concrete in masonry blocks alone, about 16 million tons could theoretically be consumed annually.

Contact: Russell Stearns, Thayer School, Dartmouth College.

Reports: Hansen, W.C., *Journal of Materials*, Vol. 2, June, 1967, 408-431. Powers, T.C., *ACI Journal*, Vol. 51, Feb. 1955, 497-516, 785-811.

Proceedings of the Third Mineral Waste Utilization Symposium, jointly sponsored by Bureau of Mines and IIT Research Institute, Chicago, Illinois, March 14-16, 1972.

Klimmek, Charles A., "Utilization of Waste Glass in Portland Cement Concrete," Thayer School of Engineering, Dartmouth College, June 1970.

Product: Tekbloks®, Tekbriks®

Description: Glass and many other aggregates may be used in the formation of a unique block made with a process patented by Tekology, Inc. In the manufacturing process, an aggregate is combined with portland cement, water and common chemicals. The mixture is then subjected to pressure of several thousand pounds per square inch. This causes a chemical reaction between the cement, chemicals and water, creating the patented Tek adhesive binder. Simultaneously, the desired product shape is formed, either into conventional shapes or into interlocking that require no mortar. Since waste products such as mine tailings can be used, a low value would be placed on the glass unless it was needed for decorative facing. The existance of this market for glass will depend on the success Tekology has in establishing itself across the country.

Status of Development: Demonstrated in a 4-bedroom, tri-level house built in Richmond, Virginia by Reynolds Metals.

Unique Advantages: New construction product offering several cost advantages. Uses about 90 percent waste materials.

Constraints: Glass must compete with very low value aggregates such as mine tailings.

Plant Investment: Medium

Quality of Glass Required: Can be heavily contaminated.

Economics: Value - $0-$3/ton
Recovery Cost - $1-$3/ton

Market: Will compete in the bricks and concrete block market where total aggregates amount to well over 40 million tons per year.

Contact: James Ryan, President, Tekology Corporation, Palisades Park, New Jersey.

Reports: Environmental Science and Technology Reprint - "Building Bricks from the Waste Pile," June 1972.